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The Integrator

A publication from the Mission Services Program Office of NASA Goddard Space Flight Center

Features

Code 450 Mission Services Program

TDRS-J: Launched Without a Hitch!

The Tracking and Data Relay Satellite (TDRS) Project (GSFC Code 454) successfully launched TDRS-J on December 4, 2002 from Kennedy Space Center. This satellite, the final constituent in the series of TDRS-H, I, J spacecraft, is the latest addition to NASA's communications satellite network.

Look for details about the TDRS-J launch in the article on page 32.

In This Issue ...

CODE 450

Mission Services Program

A Message from the Associate Director / Program Manager for Mission Services

You may have observed that the number of pages in this issue of *The Integrator* is especially substantial. Since this publication represents an overview of MSP events and activities, you can surmise that our team has been quite busy during the past few months!

In early December, we launched TDRS-J, the final in a series of enhanced communications satellites designed to supplement the fleet of original TDRS spacecraft. The launch proceeded flawlessly, and TDRS-J is now undergoing on-orbit tests. Congratulations to the entire team of civil servants and contractors who made this endeavor a success!

The MSP team also enabled two other important launch events recently—supporting the ICESat mission in January and SORCE in February. The Ground Network provided support for these two launches, and continues to provide operational communications services for both missions.

The MSP is also actively working to shape the future of space communications. We are managing a study examining the feasibility of using optical laser communications technology for a mission to Mars. In addition, the MSP's Low Power Transceiver (LPT) Communications and Navigation Demonstration on Shuttle (CANDOS) experiment recently proved a number of new capabilities and technologies that will greatly influence future space communications architectures.

The Integrator contains articles on all of these topics and more! Please take time to peruse this issue to learn more about the many successes and achievements the MSP team has accomplished and enabled.

Finally, I realize that all of us in the "NASA family" have been affected to some degree by the catastrophic events involving the Shuttle Columbia. This tragedy reminds us that the services the MSP team provides are of vital importance to NASA. The Space Network, Ground Network and Fight Dynamics Facility routinely support the Shuttle, providing communications, tracking, and navigation capability throughout each mission. In fact, the Space Network was receiving telemetry from Columbia as it made its fateful descent. This data will prove invaluable to investigators as they strive to understand and explain the events that transpired during Columbia's final flight. There is perhaps no greater reminder that the functions and services we provide are essential to NASA's success—let's continue to work together to ensure that our customers can rely on us to supply them with the first-rate communications, tracking, and navigation services they deserve.

Phil Liebrecht

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CODE 450

Mission Services Program

NASA To Offer Follow-on Contracts at Goddard

In August 2002, NASA decided not to exercise the option that would have extended the Consolidated Space Operations Contract (CSOC) for an additional five years. Instead, the Agency will procure the needed services via several separate contract awards. Goddard's requirements will be supported through two Work Packages—the Near Earth Networks Services (NENS) and the Mission Operations and Mission Services (MOMS) contracts.

The NENS contract will provide tracking and data acquisition services for near-Earth customer missions. The work will include operation and maintenance of NASA's Space Network (SN) and Ground Network (GN); hardware and software development; and the performance of sustaining engineering, logistics, and facilities management. NENS will also involve performance of customer commitment management activities, such as development and maintenance of SN and GN customer requirements and commitments documents, and interface documentation for interfaces with other NASA and non-NASA networks. In addition, the NENS contractor will perform modeling and loading studies to demonstrate the feasibility of future missions, assess SN and GN workload, and carry out architectural assessments.

MOMS will encompass all mission phases, including concept, formulation, development, operations, and decommission. MOMS support will be provided to all missions managed at Goddard, for both the Space Science and Earth Science Enterprises. Mission operations elements of the contract will include flight operations, mission planning and scheduling, maneuver planning, flight dynamics, and Level Zero data processing support. Mission services to be provided include engineering studies, ground system development and re-engineering, spacecraft integration and test, sustaining engineering activities, advanced information technology tools and techniques, and advanced flight dynamics tools and techniques.

NASA released the draft Requests For Proposal (RFPs) for these procurements on March 7, 2003 (*http://prod.nais.nasa.gov/cgi-bin/eps/sol.cgi?acqid=104633*). More information about NENS and MOMS is available on line at *http://foundation.hq.nasa.gov/newsinfo/contracts/smcds.html*.

External Audit News Flash!

The Mission Services Program (MSP) was visited by an auditor from National Quality Assurance (NQA), NASA's ISO 9000 third party registrar on February 13, 2003. The MSP came through the audit with flying colors! This MSP audit was part of the semiannual external audit process required by ISO 9000. The auditor focused on compliance with GPG 1060.2, Management Review And Reporting For Programs And Projects, and readiness to meet the new ISO 9000:2000 standard that GSFC will register for in August. Special thanks are due to Roger Clason/Code 453, who spent over an hour walking the auditor through the entire MSP reporting chain, from the STDN Daily all the way up through the Management Status Review with the Program Management Council.

By Kevin McCarthy/
Code 450

For additional information, please contact the author via email (Kevin.P.McCarthy@nasa.gov) or telephone (301-286-9516).

Extending Themselves To Broaden Others

Mission Services Program personnel have been actively participating as speakers for various events. In October, the Consolidated Space Operations Contract (CSOC) contractor at Wallops Flight Facility supported an American Heritage Week celebration with displays, information, and gifts for the public—many of whom were students from the University of Maryland Eastern Shore campus. In November, Phil Liebrecht spoke to 60 Churchill High School students (two classes) for the Achievement Counts Program that is sponsored by the Maryland Business Roundtable. Also in November, Joe Stevens represented the Space Network Project and GSFC by participating in a panel discussion for a World Space Week Seminar at Roosevelt High School in Greenbelt, Maryland. His audience was 120 high school students who were exploring career opportunities in the Space industry.

By Rosemary Bruner/GSFC Code 450

For additional information on these and other outreach opportunities, please contact the author via telephone (301-286-2648) or email (Rosemary.V.Bruner@gsfc.nasa.gov).

MSP Contractors Assist NASA Outreach Program

A team of four GSFC contractors (Linda Curtis/HTSI, Marilyn Glass/HTSI, Eric Mathis/HTSI, and Nikki Matharu/CSC) recently completed the capstone class for the Master's Degree program in Technology Management at University College/University of Maryland. This particular class was of special relevance to NASA, as the team's class project produced a marketing plan for the NASA's Space Hope Program. Using skills gained from previous courses and data from Space Hope and other sources, the team formulated a marketing plan that will facilitate the development and expansion of the program in the city of Baltimore, and potentially in cities near other NASA centers.

This group of students (plus Bill Ihnat/CSC) has assisted the Space Hope Program during two previous projects for graduate studies. Those projects addressed issues related to systems analysis and design and project management.

Space Hope is a collaborative effort between NASA, the city of Baltimore, Honeywell Technical Services Incorporated, and other partners. The program is designed to train and equip disadvantaged Baltimore City residents with specific Information Technology skills that correspond to NASA and the aerospace community's needs. Space Hope also provides participants with mentoring and job placement services. The program recently celebrated the graduation of its first class and the job placement of two of the eight students; placement of the remaining students is expected within the next 30 days.

For more information about the Space Hope Program, please contact Linda Slaughter at 443-885-3424.

By Eric Mathis/HTSI

The Code 450 organizational realignment became effective officially on November 17, 2002.

MSP Manages Laser Communications Feasibility Study

Laser Communications (LaserComm) may be the wave of the future for deep space satellite communications. Its increased bandwidth and tight beam dispersion enable transmissions of large volumes of scientific data over the vast distances of our solar system. For applications closer to Earth, LaserComm may also provide data rate communications between satellites in excess of 10 Gbits/second. A key advantage also includes the potential for significant reduction in payload power, size, and weight.

The Mission Services Program has been assigned the responsibility for managing a feasibility study of a Laser communications experiment for the Code S Mars Telesat mission. The Mars Telesat, scheduled for launch by JPL in October 2009, will orbit Mars and provide two-way relay services between Earth and Mars explorers such as the Mars Reconnaissance Orbiter and Mars Sample Return. The primary communications link of the Mars Telesat will be Ka-band, with X-band secondary and emergency links. It is expected that the proposed LaserComm link will provide an order-of-magnitude improvement over that of Ka-band, with respect to scientific data returned to Earth. Using conventional Radio Frequency (RF) communications, the Mars Reconnaissance Orbiter will take 21 months to map 20% of the Martian surface. LaserComm will allow the entire Martian surface to be mapped in just four months! The study is currently examining data rates of up to 100 Mbits/second when Mars is closest to Earth.

The optical communications feasibility study began in November 2002, when a NASA Defense Purchase Request (NDPR) was issued to the Massachusetts Institute of Technology/Lincoln Labs (MIT/LL) of Lexington, MA. MIT/LL is using optical communications experience gained from supporting the Department of Defense to conduct a six-month study of a LaserComm experiment involving the link from Mars to Earth. The study is divided into two phases: a four-month study to identify preliminary architectures, followed by a two-month study to provide a conceptual design, implementation schedule, and costs.

The scope of the study includes both the flight experiment package and the LaserComm receive terminal back at Earth. The return optical link must contend with atmospheric and weather effects if the receive terminal is ground-based. A variety of optical receive terminals are being considered. High-altitude balloons, spacecraft, and ground terminals are all being studied to find the most cost-effective implementation option for an optical communications link from Mars. The Phase I report is scheduled for completion on March 13, when MIT/LL representatives will present their findings to NASA. Study completion will be in May 2003.

Ken Ford is detailed from the Earth Observing System (EOS) Program Office to the Mission Services Program to manage this study. Engineering support from the Applied Engineering and Technology Directorate (AETD) is provided by Bernard Edwards, Paul Westmeyer, and Tupper Hyde. Dr. Ted Benjamin of ITT is supporting the team with his satellite communications experience. In addition, technical support for the study is provided by the Mars Program and Optical Communications Offices at JPL.

NASA will use the results of this study for implementation planning. The Mission Services Program will provide budget numbers to Code S for POP '03-1 this summer. If there is a decision to proceed with implementation, a manager will be assigned for formulation studies in 2004 and acquisition planning.

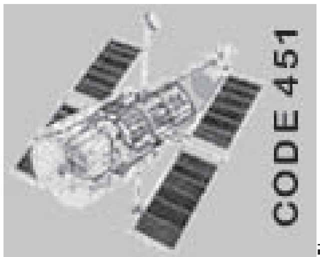
By Ken Ford/Special Assistant for Program Integration/EOS Program Office

For additional information, please contact the author via email (Kenneth.E.Ford@nasa.gov) or telephone (301-286-0011).

Be sure to check out the
Mission Services Milestone Chart
in the center of this issue.

We have updated it to reflect current dates and activities.

Further updates to this chart will be provided in future issues of ***The Integrator****.*



Customer Commitment Office

Mission Services Customer Forum To Meet in March

The Mission Services Customer Forum (MSCF) begins its second year with a meeting on March 21. The forum will be in the Building 3 Auditorium at GSFC, starting at 1:00 p.m.

At this meeting, we will feature two topics that should be of interest to both new missions and those already in orbit. The first is a mission design tool, the Integrated Design Capability. This tool includes both the Integrated Mission Design Center (IMDC) and the Instrument Synthesis and Analysis Laboratory (ISAL) at GSFC. The IMDC has been used by new missions for proposal and operations concept development work to identify mission design scenarios and their associated budgetary and technological feasibility.

The second topic is the Space Network (SN) Web Services Interface (a.k.a. SWSI), a new Space Network scheduling tool. This tool is especially useful to missions planning to utilize the Demand Access System (DAS). It facilitates mission planning, placing scheduling flexibility at the fingertips of a project's mission planner. Both of these topics should be quite interesting, and provide some insight into NASA's future.

Something new… for the MSCF. Arrangements are now being made to webcast the March MSCF. Our success will be your gain, as webcasting will facilitate access by our remote attendees. Stay tuned for the details!

For additional information about the Mission Services Customer Forum, please contact me at 301-286-9436; my email address is *Allen.J.Levine@nasa.gov*. Or drop by our website at *http://npas19.honeywell-tsi.com/mscf*. There you can find up-to-date information about the next forum and presentations from past meetings.

See you there!

By Al Levine/GSFC Code 451

MSP Team Visits Japan

A NASA delegation, led by Mr. Jim Bangerter, NASA Code 451 Mission Commitment Manager for Reimbursable and Expendable Launch Vehicle (ELV) Missions, traveled to Tokyo, Japan in November 2002 for Technical Interchange Meeting (TIM) # 5 with NASDA HTDRP (H-IIA/TDRS Data Relay Project) Representatives. Team members from Goddard included Mr. Stan Drezek, HTSI CSR; Mr. Tom Russell, HTSI NOM; and Mr. David Wampler, ITT CLASS. The NASDA delegation was led by Mr. Takahisa Sato, NASDA HTDRP Project Manager; Mr. Naohiko Kotake, H-II A Launch Vehicle Project Team Office; Tetsuo Kitamura, Launch and Test Facilities Development Office; Yuusuke Suzuki, Senior Engineer H-IIA Project Team; and Ryoko Kimura, H IIA Project Team; along with additional NASDA H-IIA Project and Contractor Team Members.

After two days of meetings in Tokyo, the NASA team, escorted by Kotake-san, Kitamura-san, and Suzuki-san, traveled to Tanegashima Island off the southern coast of Japan. While on the island, the group toured the Tanegashima

Chisato Iida (l) and Jim Bangerter (r)

Space Center. We were welcomed by Mr. Chisato Iida, Tanegashima Space Center Director, who presented an overview of the Space Center to the visiting delegation. A tour of the Center, led by Ms. Yuuko Kubota (Tanegashima Space Center PAO), provided stops at the Yoshinobu Launch Complex, Takesaki Range Control Center (with briefing by Ms. Kaoru Sakamoto), Engineering facilities, and the Nakanoyama Telemetry Station.

Under the HTDRP agreement being negotiated with NASDA, NASA expects to provide Space Network support for two H-IIA launches—a precursor flight in 2004, and the SELENE Mission in 2005. SELENE will be the first Japanese large-scale lunar orbiter.

From l to r:
Naohiko Kotake, Tetsuo Kitamura, Stan Drezek,
Ms. Kaoru Sakamoto, Thomas Russell, Jim Bangerter
at the Range Control Center

TIM # 6 is currently scheduled for late April 2003, and will be hosted by Mr. Bangerter at Goddard Space Flight Center.

Please visit http://www.nasda.go.jp/about/centers/tnsc/index_e.html for more information on Tanegashima Space Center, and http://www.nasda.go.jp/projects/sat/selene/index_e.html to learn more about the SELENE Mission.

By Jim Bangerter/Code 451

Expendable Launch Vehicle News

Delta IV became the second "heavy lifter"—joining Atlas 5 as successful Evolved Expendable Launch Vehicles (EELV)—following its launch on November 20, while an upgraded Ariane 5 rocket failed shortly after launch on December 11.

Delta IV, one of the next-generation "heavy lifters," made its maiden flight on November 20, 2002. The EELV was launched from the rebuilt pad 37B at Cape Canaveral, Florida—a launch pad last used 35 years ago to launch Saturn rockets. Liftoff occurred at 5:39 p.m. EST. Following launch, the Delta IV placed a Eutelsat W5 communications satellite into stationary orbit.

The second launch for Delta IV was planned for early February, but has been delayed out of respect for the astronauts lost in the Columbia accident on February 1, 2002. Schedulers will seek a launch date in March for the next attempt. This mission will carry a Defense Satellite Communications System (DSCS), which will be the first military payload for the EELV program.

It should be noted that the U.S. Government was reviewing the Federal rocket launch program to assess the need for both Lockheed and Boeing to provide EELV program support. Apparently, this process or exercise takes place each year, but following the loss of the Space Shuttle Columbia, the decision to drop one launcher may be a moot point.

The Ariane 5 program experienced a major setback when the first upgraded Ariane 5 vehicle was lost shortly after liftoff on December 11, 2002. The vehicle was carrying two communications satellites. This setback will have a domino effect on the development of the ultra-heavy Ariane 5. The ultra-heavy vehicle is to be the first Ariane 5 supported by TDRS. European Space Agency (ESA) officials will suspend efforts on the ultra-heavy

(continued on page 10)

(continued from page 9)

vehicle, pending a review of the program. Market pressures will also come into consideration, following the successful launches of Atlas 5 and Delta IV. The ultra-heavy Ariane 5 would have a capability of placing a 12-ton payload into geosynchronous orbit.

NASDA's H-IIA vehicle, coming off two successful test flights and its first operational mission on September 10, will launch two classified payloads during the first quarter of this year. TDRS will support the H-IIA/SELENE mission to the moon in late 2005 or early 2006.

In November, members of the Goddard ELV team visited the National Space Development Agency of Japan (NASDA) in Tokyo, for the 5th NASDA/TDRSS Technical Interchange Meeting. (See the article by James Bangerter on page 8).

By Joe St. John/Lockheed Martin

For further information on ELV support, please contact Jim Bangerter/GSFC via telephone (301-286-7306) or email (James.Bangerter@nasa.gov)

Upcoming Significant ELV missions (dates subject to change)	
Mar (NET)	Delta IV/DSCS A3 from Cape Canaveral, FL
Mar (NET)	Titan 4B/Milstar 2-F4 from Cape Canaveral, FL
Mar 14	Atlas 5/Hellas Sat 2 from Cape Canaveral, FL
Mar 25	Pegasus/Galex from the Eastern Range, offshore coastal FL
1st Qtr	H-2A from Tanegashima, Japan
Apr 4 (NET)	Sea Launch 11 from mid-Pacific location
Apr 10	Atlas 3B/AsiaSat 4 from Cape Canaveral, FL
May (NET)	Titan 2/DMSP from Vandenberg AFB, CA
May 25 (NET)	Sea Launch 12 from mid-Pacific location
May 30	Delta 2/Mars Rover-A from Cape Canaveral, FL
Jun 9	Titan 4B/NRO from Cape Canaveral, FL
Jun 25	Delta II/Mars Rover-B from Cape Canaveral, FL

Tropical Rainfall Measuring Mission Going Well

The Tropical Rainfall Measuring Mission (TRMM) spacecraft has recovered nicely after experiencing a solar array anomaly in September/October 2002 (for details on this event, see the TRMM article in the November 2002 issue of *The Integrator*). Operations are nominal and all instruments are producing science data without mishap.

The TRMM team, including Flight Software personnel, developed and tested several command sequence changes which aim to prevent the spacecraft from going into Sun Acquisition mode, should the +Y Array cease tracking. This effort was deemed necessary since the –Y Array remains parked at the feathered position, making it that much more involved to get back to the Nominal Mission Mode. These command sequence changes were uplinked to the spacecraft on 05 February 2003. On a related note, TRMM Delta-V (orbit adjust) maneuvers have been occurring over somewhat longer (~10 day) intervals of late, due to the parking of the –Y array and the reduced solar flux intensity experienced by the spacecraft since our last report.

After several weeks of detailed preparation, the TRMM Mission Director hosted the TRMM Controlled Re-Entry Plan Review on 29 January 2003. This review went well, and the team awaits further direction from NASA Headquarters.

After Delta-V maneuver #426 was executed on 30 January 2003, approximately 199 kg of fuel remained onboard the spacecraft. The tentative plan calls for cessation of orbit adjust maneuvers once the remaining fuel level reaches 134 kg. At that time the spacecraft will commence drifting down to an altitude of 320 km. The actual controlled reentry effort will take place afterward. TRMM will continue to collect science data during its drift down (probable minimum duration of the drift down is approximately one year, but it could take longer).

By Lou Kurzmiller/TRMM FOT

For additional information regarding TRMM, please visit the TRMM website (http://trmm.gsfc.nasa.gov/index.html) or contact the author (lkurzmil@pop500.gsfc.nasa.gov) or Vickie Moran/TRMM Mission Director (vickie.e.moran.1@gsfc.nasa.gov).

Ground Network Enables ICESat Mission

On January 12, 2003 at 4:45 p.m. PST, NASA successfully launched the Ice, Cloud and Land Elevation satellite (ICESat) aboard a Boeing Delta II rocket from Vandenberg Air Force Base, California. Separation occurred 64 minutes after launch, and the Svalbard, Norway Ground Station made initial contact with ICESat 75 minutes after launch. The CHIPSat spacecraft was also launched aboard the same Delta II. ICESat's designed lifetime is for three years of operation with a five-year goal.

ICESat's only instrument, the Geoscience Laser Altimeter System (GLAS), is comprised of a laser system for measuring distance, a star-tracker attitude determination system, and a Global Positioning System (GPS) receiver. As ICESat precesses westward with Earth's rotation, the laser transmits photons toward Earth. These photons are reflected off Earth's surface or clouds, and are captured by detectors aboard ICESat. Data correlated from the star-tracking camera and the GPS enable GLAS to calculate the position and elevation of every measurement initiated by the laser.

The result of the ICESat mission will be a precise measurement of Earth's polar ice masses, sea ice, topography, and cloud cover. The precision of measurement is such that the GLAS instrument will be able to detect a change in the elevation of an ice sheet as small as 1.5 cm (.6 in.) per year. This capability will provide much-needed answers to questions about the state of the Antarctic and Greenland ice sheets. Such precise measurement of the ice sheets has been impossible before, due to the harsh weather conditions encountered during land-based studies.

The Mission Operations Center (MOC) for ICESat is located at the University of Colorado Laboratory for Atmospheric and Space Physics (CU/LASP). The MOC is responsible for mission planning and scheduling, commanding, health and safety monitoring, and nominal flight dynamics support. Goddard's Flight Dynamics Facility provides early mission orbit determination.

Once the GLAS instrument is fully activated, ICESat will receive four to five passes per day from the Ground Network polar ground stations. The Earth Observing System Data Operations System (EDOS) captures the data at Goddard, and provides preprocessing, initial distribution, temporary storage of raw data, and permanent storage of processed data. ICESat is expected to generate approximately 5.8 GB of Level 0 data per day.

By Don Davenport/HTSI

For more information, please contact the author via email (Donald.Davenport@Honeywell-TSI.com) or telephone (301-286-0702).

The ICESat/CHIPSat launch, aboard a Delta vehicle on January 12, 2003

ICESat Specifications	
Mass:	959 kg (306 kg for GLAS)
Power:	640 W (322W orbit average for GLAS)
Orbit:	600 km circular
Inclination:	94 degrees

GN Supports SORCE Launch

The SOlar Radiation and Climate Experiment (SORCE) was successfully launched and inserted into orbit by a Pegasus XL rocket on February 25, 2003. The launch was picture perfect, and terrific images of the actual rocket drop and ignition were obtained. The SORCE payload was mated with the Pegasus rocket that was, in turn, attached to the "Stargazer" L-1011 aircraft. The Stargazer, carrying Pegasus and SORCE, traveled approximately 40,000 feet above the open ocean, where it released the Pegasus rocket. The rocket then underwent a free-fall in a horizontal position for five seconds before igniting its first stage rocket motor. The rocket ignited perfectly, the first two stages performed nominally, and the third stage actually took the payload into orbit and maneuvered it into the proper position before detaching successfully. The author thoroughly enjoyed viewing the rocket launch and following the progress of the orbit insertion over the voice loops.

SORCE is a small free-flying satellite carrying four scientific instruments that will measure the solar radiation incident at the top-of-the-Earth's atmosphere. This mission is one element of NASA's Earth Observing System (EOS), which is the major observational and scientific element of the U.S. Global Change Research Program. SORCE will operate on-orbit for a period of five years, with a design goal of six years.

The Space Network supported SORCE during the launch and early orbit phases, and the Ground Network is providing operational support from stations in Wallops Island, Virginia; Santiago, Chile; and Hartebeesthoek, South Africa.

Scientists and engineers at the University of Colorado's Laboratory for Atmospheric and Space Physics (LASP) designed, built, calibrated, and tested the four scientific instruments on SORCE. LASP is operating the satellite from its Mission Operations Center in Boulder, Colorado for the duration of the mission. Orbital Sciences Corporation in Dulles, Virginia developed the spacecraft carrying the instruments. The SORCE spacecraft is three-axes stabilized, with a control system to point the instruments at the Sun and at the calibration stars.

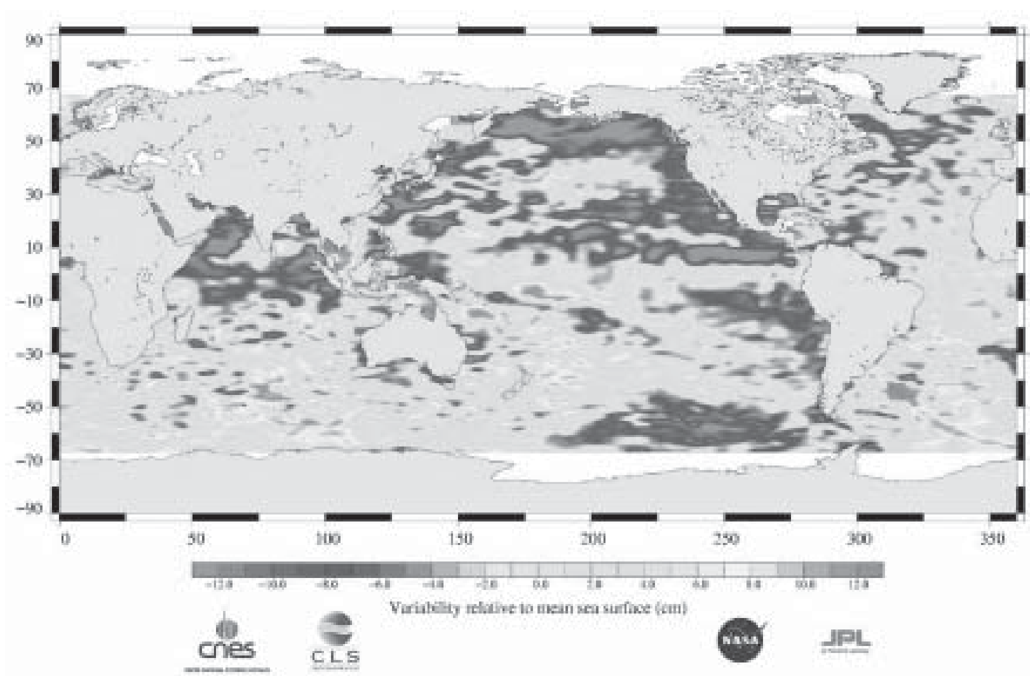
By Lynn Myers/GSFC Code 451

For further information check out the following websites: http://lasp.colorado.edu/sorce, http://earthobservatory.nasa.gov/Library/SORCE, and http://www.orbital.com/index.html

TOPEX/Poseidon, Jason-1, and Their Partners in Oceanography

The U.S.-French TOPEX/Poseidon (T/P) satellite continued to function exceptionally well through the midpoint of its eleventh operational year. A six-month cross-calibration between T/P and Jason-1 was completed last year, and the T/P orbit was successfully modified in August-September 2002,

Jason, Cycle 002
Period: 25/01/2002 - 04/02/2002



First science data from Jason-1 showing ocean sea-surface variability across the Earth in early 2002. This 10-day data set provides more information than the past collective 100 years of ship-based measurements by a series of propulsive maneuvers. The new T/P orbit will enhance overall science data quantity and quality in its "tandem" mission arrangement with Jason-1.

It should be emphasized that, even though T/P and Jason-1 jointly provide extremely accurate information on ocean surface topography and sea-surface height, they are only part of a larger constellation of NASA Earth Science satellites providing valuable information on the world's oceans. Although topography data from T/P and Jason-1 are the key to understanding the critical relationship between ocean circulation and climate, water salinity, sea-surface wind speed/direction, and Earth gravity models are all used to provide a synergistic understanding of this ocean-climate connection. Projects to remotely measure salinity are currently in the planning/proposal stages, but two recently launched satellites (QuikSCAT and GRACE) have enabled wind speed and gravity field measurements to be collected and distributed to oceanographers and meteorologists worldwide.

Why are these ocean studies so important to climate? Remember that over 70% of Earth's surface is covered by water. These oceans, streams, seas, and lakes continuously exchange heat, moisture, and carbon dioxide with the atmosphere, which in turn controls weather patterns and long-term climate changes. Atmospheric changes are primarily driven by heat transfer with the surface water, and Earth's oceans store more heat in their upper 10 feet than the entire atmosphere!

It is clear that satellite ocean data can benefit climate research, and enhance our knowledge of closely related phenomena such as hurricanes and El Niño. However, other direct societal applications of this data include:

- Ship routing - maps of currents, eddies, and vector winds are used by both commercial and civilian ships to optimize routes
- Coral reef research - ocean temperature changes directly affect reef ecosystems
- Marine mammal research - ocean eddies attract whales, seals, and other marine mammals due to high local concentrations of nutrients and plankton
- Offshore industries - data on ocean currents and eddies are utilized by cable-laying vessels and offshore oil operations
- Fisheries management - temperature, currents, and eddies directly affect the marine food chain.

It is also evident that because trends and changes in the ocean and climate are so large-scale in nature, data of any great significance must be gathered over the longest possible time period. NASA is very aware of this fact, and has planned several missions over the coming decades to enable data collection to continue. This foresight will not only directly benefit society, but will also guarantee many important and exciting discoveries in the fields of oceanography and meteorology for years to come.

By Mark Fujishin/Manager, JPL Earth Science Mission Operations

For more information on TOPEX/Poseidon or Jason-1, contact the author via email (Mark.D.Fujishin@jpl.nasa.gov) or telephone (818-393-0573).

The Long Duration Balloon Program Launches Successful Flights from Antarctica

The Long Duration Balloon Program (LDBP) had two very successful science flights from McMurdo Station, Antarctica during January 2003. These missions were reflights of some successful experiments that have flown in the Antarctic before.

The ATIC II (Advanced Thin Ionization Calorimeter) payload was launched on December 28, 2002, and was terminated on January 21, 2003. The ATIC payload was studying Galactic Cosmic Rays. The BOOMERANG (Balloon Observations of Millimetric Extragalactic Radiation and Geophysics) payload was launched on January 6, 2003, and was terminated on January 21, 2003. Its enhanced design measured the Cosmic Microwave Background (CMB) with improved precision and spectral coverage. The flights were a complete operational and scientific success. More

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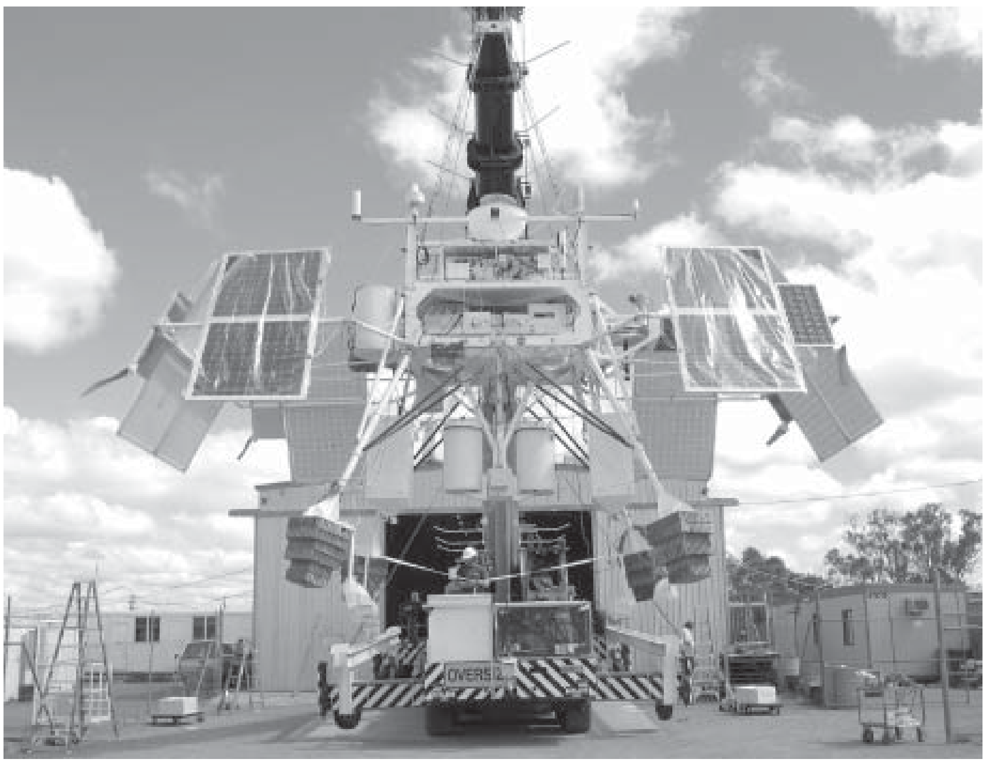
BOOMERANG on Delta launch vehicle in Antarctica

(continued from page 13)

information about ATIC can be found at *http://atic.phys.lsu.edu/aticweb/* and Boomerang at *http://cmb.phys.cwru.edu/boomerang*. Both science groups were able to send a good portion of their scientific and experiment housekeeping data real time via the Space Network (SN).

The LDBP also is preparing to launch an important flight from Alice Springs, Australia at the present time. This flight will continue to test the new Ultra Long Duration Balloon (ULDBP) vehicle. This will be the largest super-pressure balloon to ever fly (over 21 million cubic feet). These balloons can carry up to 2200 pounds of scientific experiments for durations of up to 100 days. More information about the ULDB vehicle can be found at *http://www.wff.nasa.gov/~code820/uldb/index.htm*. This flight will carry the NIGHTGLOW experiment, which includes telescopes that measure the ultraviolet glow of Earth's atmosphere. All of the NIGHTGLOW scientific data will to be relayed real time through the SN. More information about NIGHTGLOW can be found at *http://nightglow.gsfc.nasa.gov/ng.html.*



NIGHTGLOW on launch vehicle in Alice Springs, Australia

The LDBP will also be flying the TDRSS High Gain Antenna developed by GSFC/WFF/Balloon Projects Branch on the ULDB test flight in Australia. This development will allow scientists flying on ULDB or LDB balloon missions to downlink science data at much higher rates. Plans are to test data rates up to 150 Kbps through the Multiple Access (MA) link.

By Bryan Stilwell/ NSBF/Physical Science Laboratory, NMSU

To learn more about the LDBP, please contact the author via email (stilwell@master.nsbf.nasa.gov) or telephone (903-723-8097).

RXTE's Seventh Year a Productive One!

The Rossi X-ray Timing Explorer (RXTE) began its eighth year of guest observer operations on March 1, 2003, with 120 accepted observing programs using RXTE's Proportional Counter Array (PCA) and High Energy X-ray Timing Experiment (HEXTE). Many of these programs will use the All Sky Monitor (ASM) instrument to trigger the start of the observations according to a change in the behavior of a target.

One of the goals of RXTE is to study sources that suddenly go from being too faint for RXTE to detect, to some of the brightest sources in the sky. RXTE finds these sources using either the ASM or the PCA.

The ASM was designed to scan most of the sky every 100 minutes, looking for relatively bright new sources. Figure 1 shows outbursts of four black hole candidates (BHCs) and one pulsar that ASM detected last year. All of these were observed further by RXTE instruments in the last year, and all but 4U 1543-475 are still being observed several times a week with the PCA and HEXTE. To give you an idea of the brightness observed for these BHCs, the ASM gives 75 counts/sec for the Crab Nebula, so these sources ranged from 1/2 to 6 Crabs – bright.

The most convincing evidence that a BHC is a black hole comes

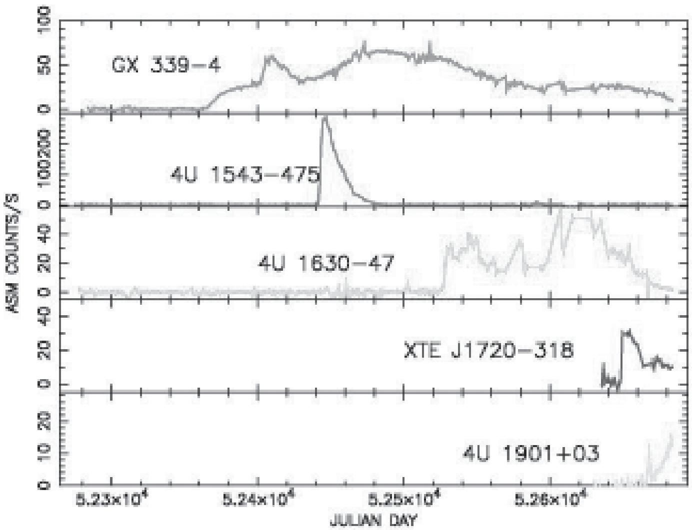


Figure 1. X-ray fluxes from 5 transients

from optical measurements of the velocity of a companion star around the black hole. GX 339-4 is the first black hole to be detected based on an outburst measurement of nitrogen lines, which are believed to be excited by the X-rays emitted by hot gas near the black hole. British observers derived a mass for the black hole/ companion star system of approximately 5.8 solar masses, and a binary period of 1.7 days. For 4U 1543-475, the optical spectrum in between outbursts gave a similar mass and binary period (1.2 days).

The other BHCs in Figure 1 (4U 1630-475 and XTE J1720-318) do not have optical identifications, but are classified as black holes because their X-ray and radio properties are similar to those of known black holes. They indicate a bright phase in which the accretion disk (the matter swirling around a black hole) appears to be responsible for more than half the x-rays. As the radiated energy decreases, a change occurs; the individual X-rays that emerge are more than 20 times more energetic and the disk is hidden or not present.

For some black hole sources, the X-ray flux oscillates. When they occur, these oscillations are a prime target of RXTE studies.

In contrast to the BHCs, the fifth and most recently detected source shown in Figure 1 (4U 1901+03) is a recurrence of a transient source seen in 1971. In its initial observation, the PCA saw that this source emits pulses with a 2.8 second period. RXTE is carrying out observations for astronomers at the Massachusetts Institute of Technology and the University of California San Diego to find the Doppler shifts and the binary period of this source, and to search for cyclotron absorption lines.

RXTE's PCA is capable of finding even fainter new sources. GSFC astronomers use this RXTE feature to search for sources near the center of our Galaxy. Most of the newly detected sources are neutron stars. Among them are the accreting neutron stars with the shortest known periods—SAX J1808-3658 at 2.5 ms and XTE J1751-305 at 2.3 ms.

By Jean Swank/RXTE Scientist

For further information about RXTE discoveries, please contact the author via email (jswank@lheapop.gsfc.nasa.gov).

Landsat-7 Mission Maintains Exemplary Performance, and Postures for Ground Contingencies

Landsat-7 Flight Operations Exceeds Six Sigma Performance

Landsat-7 Flight Operations had an outstanding year in 2002, capping it off with the celebration of 366 days without an operator error. This performance is well above the Six Sigma standard of proficiency the Landsat-7 Flight Operations Team (FOT) strives for, and this accomplishment nearly beats their record of 53 weeks without an error.

Landsat-7 Flight Operations is a complex arena, presenting nearly 940 thousand "opportunities" a year to succeed. Apart from the daily rigors of normal operations, the Landsat-7 FOT enhanced the spacecraft's star catalog, performed 22 delta velocity maneuvers, executed a detailed dual-burn delta inclination maneuver, performed special instrument cool-down imaging, addressed several spacecraft anomalies, dodged the Leonid meteor shower, and successfully performed calendar year-end rollover operations. In conjunction with all of these challenging spacecraft activities, the Team re-engineered all of the control center interfaces to implement the Landsat-7 backup Mission Operations Center (bMOC), and also helped to integrate the Alice Springs, Australia ground station into its network.

Landsat-7 Flight Operations is already off to a great start in 2003. Go Landsat-7 Team!!!

Backup Mission Operations Center (bMOC) Operations Readiness Review and Activation

The Landsat-7 backup Mission Operations Center (bMOC) Operations Readiness Review was held on December 11, 2002 at

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Tegan Collier, Landsat-7 Project Manager, presents the "Six Sigma Error-Free Operations" award to Ed Callaway, Landsat-7 Real-time Operations Supervisor and Rich Lonigro, Landsat-7 FOT Manager

(continued from page 15)

the Datalynx facility in Columbia, Maryland. The Landsat Program deemed the bMOC fully capable to assume operations for a minimum of 30 days, should circumstances shut down the primary MOC at GSFC. bMOC implementation required extensive changes to nearly all Landsat-7 flight operations interfaces, including interfaces to the primary MOC. The Landsat Ground Network sites were incrementally phased-in during January, marking the final implementation steps for the MOC/bMOC. The bMOC will be exercised on a monthly basis for planning and real-time operations. The United States Geological Survey (USGS) has the option to direct a partial or full transfer of operations functionality to the bMOC, allowing the agency to tailor its response to the outage and situation.

Landsat-7 Year End Transition

Landsat-7 Flight Operations successfully conducted year-end operations activities to accommodate the calendar year rollover and spacecraft onboard timing issues. Imaging was suspended for 24 minutes during rollover and a subsequent Earth shadow. Operations and image taking resumed with no problems encountered.

By Tegan Collier/HTSI

For additional information about Landsat-7, please visit http://landsat7.usgs.gov/index.php.

White Sands Complex Considered for Solar Dynamics Observatory Ground Station Site

The White Sands Complex (WSC) is being considered as a site for a ground station for NASA's upcoming Solar Dynamics Observatory (SDO) mission. SDO is the flagship mission in the Agency's Living With A Star Program. SDO will collect data from the solar atmosphere that will help scientists understand the sun's influence on Earth and near-Earth space.

The SDO spacecraft will be placed in a geosynchronous orbit, hovering approximately 35,000 km above Earth at a longitude of 104 degrees. It will be in full view of WSC. SDO will transmit Ka-band science data at a rate of 150 Mb/s, 24 hours per day, for at least five years. The spaceborne observatory will also utilize S-band communications to transmit and receive housekeeping data and commands.

Two fully redundant, nine meter antennas will be used to communicate with SDO. Each antenna will be capable of receiving both S-band and Ka-band data. NASA is considering placement of these antennas at WSC—with the prime antenna located at Cacique (the White Sands Ground Terminal) and the backup at Danzante (the Second TDRSS Ground Terminal). Located in White Sands, New Mexico, WSC ideally located for Ka-band communications, since use of that wavelength requires clear weather with little or no precipitation.

In addition, NASA is also possibly planning an SDO Data Distribution Center (DDC) at WSC in the Caicque facility, collocated with the prime SDO antenna. The DDC will receive, store, and distribute SDO raw data, but will not perform data processing functions. After the raw data is received from the spacecraft, the DDC will send data streams in near real-time to Stanford University; the University of Colorado's Laboratory for Atmospheric and Space Physics; and the Naval Research Laboratory in Washington, DC. The DDC will store the raw data for 30 days for possible retransmission, if needed.

Stay tuned to future issues of *The Integrator* to learn more about this project as details unfold.

For more information, please contact Raymond Pages via email at Raymond.Pages@nasa.gov.

ADEOS-II Is In Orbit!

On December 14, 2002, at 10:41 in the morning Japanese Standard Time (01:41 UT and 8:41 PM EST, December 13, 2002) the Advanced Earth Observing Satellite II (ADEOS-II) spacecraft, nicknamed Midori-II, was successfully launched aboard a Japanese H-IIA rocket from Tanegashima Space Center on an island in southern Japan. The launch capped several years of intense preparation by people in the U.S., as well as Japan. ADEOS-II is performing well, and is currently in the checkout phase. It is scheduled to be fully operational in April 2003. The National Oceanic and Atmospheric Administration (NOAA) will be using data from some ADEOS-II sensors in its operational systems.

ADEOS-II launched December 14 aboard a Japanese H-IIA rocket from Tanegashima Space Center
(Photo courtesy of Dan Duffy)

Mission Description

ADEOS-II will continue ADEOS's mission of monitoring and investigating the causes of climate changes occurring in the world, expansion of the ozone holes, and other global environmental changes. ADEOS-II is equipped with five main science sensors, and several ancillary instruments.

ADEOS-II can operate in one of two modes: with (Mode I) or without (Mode II) an IOCS (Inter-Orbit Communication Subsystem) to transmit the data stored on its onboard tape recorders. The U.S. ground stations receive the same number of passes in either mode, but the network load is heavier in Mode II. The expected Mode I/Mode II split is 80% Mode I and 20% Mode II, but the ground stations are designed to handle 100% Mode II.

Main Science Instruments

The **Advanced Microwave Scanning Radiometer (AMSR**) will observe various physical phenomena concerning water by receiving microwaves naturally radiated from Earth's surface and atmosphere (for example, water vapor content, precipitation, sea surface temperature, sea surface wind, sea ice, soil moisture, etc.).

The **Improved Limb Atmospheric Spectrometer-II (ILAS)**, developed by the Environmental Agency of Japan (EA), now the Ministry of the Environment (MOE), will observe the atmospheric limb absorption spectrum from the upper troposphere to the stratosphere, using sunlight as a light source (solar occultation technique). Its objectives are to monitor and study changes in the stratosphere that are triggered by emissions of chlorofluorocarbons (CFCs), and to evaluate the effectiveness of worldwide emissions controls of CFCs. The ground processing is under the management of the National Institute of Environmental Studies in Japan.

The **Global Imager (GLI)** is an optical sensor to observe the reflected solar radiation from Earth's surface, including land, ocean, and clouds. It detects infrared radiation, providing a measure of physical properties such as chlorophyll, dissolved organic matter, surface temperature, vegetation distribution, vegetation biomass, distribution, and albedo of snow and ice, etc. These data may be used for inferring the global circulation of carbon; monitoring cloud, snow, ice, and sea surface temperature; and understanding the primary marine production cycle.

NASA's **SeaWinds scatterometer** will provide high-accuracy wind speed and direction measurements over at least 90% of the ice-free global oceans every two days. SeaWinds will provide a continuing set of long-term wind data for studies of ocean circulation, climate, air-sea interaction, and weather forecasting.

The **Polarization and Directionality of the Earth's Reflectances (POLDER)** instrument will observe the polarization and directional and spectral characteristics of the solar light reflected by aerosols, clouds, oceans, and land surfaces. POLDER is a wide field of view imaging radiometer that will provide the first global, systematic measurements of the solar radiation reflected by the Earth/atmosphere system.

Ground System

The NGN, or NASA/NOAA Ground Network, provides ground support services to ADEOS-II. The term NGN has no official meaning outside the context of the ADEOS-II Project. By agreement, NOAA provides a substantial part of the funding for the NGN, and NASA provides the tracking and data distribution resources. These resources consist mainly of the Alaska Synthetic Aperture Radar (SAR) Facility (ASF), the Wallops Ground Station (WGS) located at Wallops Flight Facility, and the interconnecting communications networks (provided by NASA's Earth Science Data and Information System, or ESDIS) for data delivery.

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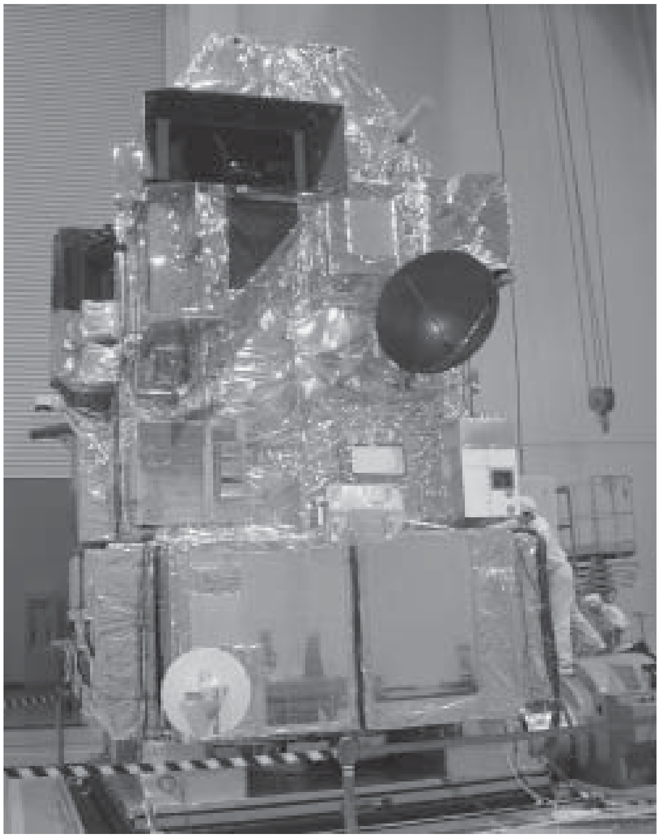


ADEOS-II undergoing integration at
Tsukuba Space Center in Japan
(Photo courtesy of Hayden Gordon)

(continued from page 17)

The Geophysical Institute of the University of Alaska, Fairbanks operates the ASF. Due its high latitude, ASF is well suited to tracking polar orbiting satellites, such as ADEOS-II. ASF possesses an 11-meter antenna, on which ADEOS-II has first priority. It also has a 10-meter antenna that can be used as a backup, on which ADEOS-II has a lower priority.

The WGS is currently operated under the Consolidated Space Operations Contract (CSOC) for NASA. WGS is a multi-project station and has an 11-meter antenna that tracks ADEOS-II, as well as other satellites. At WGS, there is no backup antenna, as there is at ASF.

For ground communications, the NGN relies on the Earth Observing System (EOS) Mission Services Network (EMSNet), formerly EBNet (EOS Backbone Network), which is under the auspices of ESDIS at the Goddard Space Flight Center. EOS, of course, stands for Earth Observing System.

Since ADEOS-II onboard recorders are played back without rewinding, the data are transmitted in reverse order. Data strippers at the ground stations are necessary to reverse the data. The data strippers also perform Reed-Solomon decoding, frame synchronization, and sorting by APID (Application Identification).

The Wallops ground station is scheduled by the Data Services Management Center (DSMC) in White Sands, New Mexico. ASF performs its own scheduling.

By Ron Forsythe/WFF Code 589
More information may be found at http://www.nasda.go.jp/.

Go On Line To Get Information About the Space Network

The Space Network (SN) Online Information Center contains information modules beyond those for the Tracking and Data Relay Satellite System. You'll still find authoritative information about TDRSS, but we've now included information and links to other Mission Services Program and Space Network activities. There are new links to the Demand Access System (DAS) and SN Web Services Interface (SWSI) websites, and updated links to SN customer websites. The telecommunication information module update is almost complete, ensuring that the information in the website is consistent with the Space Network Users Guide Revision 8. The users guide is also available for download at *http://msp.gsfc.nasa.gov/tdrss/guide.html*.

We have updated the TDRS constellation information to include the TDRS H, I, and J deployments. If you have a specific question, use our feedback form to email it to us. We'll direct your question to the appropriate expert, and return an answer directly to you via email. As always, the calendar of upcoming events is updated monthly, listing upcoming launches and other activities of interest. The entire site is updated twice monthly to ensure information is current and accurate.

The SN Online Information Center can be found at *http://msp.gsfc.nasa.gov/tdrss/*

Detailed information is currently available on:
- The Tracking and Data Relay Satellites (including TDRS H, I, J)
- Demand Access
- The White Sands Complex including WDISC
- Guam Remote Ground Terminal
- McMurdo TDRSS Relay Terminal System
- TDRSS Telecommunication Services
- Customer Communication Systems and Products (including Transponders)
- TDRSS Applications
- Plus much more…

By Jeff Glass/FHA

CODE 452

Space Network Project

JSC Uses New UPS Release To Support Manned Space Missions

With the December 2002 installation of the latest User Planning System (UPS), a new era of scheduling human space flight missions has begun—use of flexible schedule requests for both the International Space Station (ISS) and the Shuttle.

Working closely with the Station/Shuttle Commanders in the Mission Control Center (MCC) at Johnson Space Center (JSC), the UPS staff installed and configured the new UPS release at JSC, and trained key JSC personnel in its use.

The installation of the new UPS release allowed JSC to remove its outmoded schedule request creation system, significantly reducing personnel time and hardware maintenance costs.

New UPS features employed by the JSC Commanders include:

- Recurrent Scheduling (RS) generation to automatically generate a weekly set of ISS/Shuttle flexible schedule requests.
- Submission of Replace Requests, which facilitate faster real-time rescheduling.
- Graphical representation of the intersection of ISS/Shuttle TDRS orbital views with TDRS Unscheduled Time (TUT), which allows the JSC Commanders a continuous real-time "snapshot" of available TDRS time slots—critical when real-time ISS/Shuttle rescheduling is necessary.

As predicted, there has been a significant improvement in the number of declined weekly schedule requests that need to be "de-conflicted" in real-time. Using the new UPS release, the JSC Commanders reported 50% fewer ISS/Shuttle declined schedule requests that had to be de-conflicted by hand during the STS-107 mission.

Prior to use of the new UPS release, 40 – 50 ISS requests were declined every (non-Shuttle) week, requiring time-consuming human interaction between the JSC Commander and the Data Service Management Center (DSMC) Forecast operator. Since the use of the new UPS release, the number of declined ISS requests averages 4 – 8 per week—a vast improvement!

Congratulations, JSC!

By Howard Michelsen / CSC

Further information regarding the UPS Project can be found on the WWW at http://rtsel.gsfc.nasa.gov/isolde/ups/ or contact the author via email at hmichels@csc.com.

Ka-Band Transition Project Successfully Demonstrates 600 Mbps Space Network Link

We have achieved significant progress and major successes on the Ka-Band Transition Project (KaTP) since the November 2002 *Integrator* was published. In the previous issue, we mentioned that the KaTP team was busy performing hardware integration and test activities to prepare for high data rate demonstrations scheduled for the end of 2002. During the first three weeks of December, KaTP team members successfully demonstrated a 600 Mbps Space Network (SN) communications link (a SN first!) using TDRS H and the new KaTP equipment installed at the White Sands Complex (WSC).

Considerable planning and coordination took place in advance of the demonstration tests, including the development of detailed demonstration plans and procedures. A high data rate test modulator and receiver (600 Mbps, SQPSK), and a Ka-band upconverter procured for the GN portion of the KaTP project were shipped from Wallops Flight Facility (WFF) to WSC. There they were integrated with the Ka-band test antenna system on the roof of the White Sands Ground Terminal (WSGT) to simulate a high rate Ka-band customer. Because this test antenna system is used for the ongoing TDRS H, I, J testing, the KaTP project had limited windows of opportunity to perform the demonstration tests.

The first week and a half of the demonstration at WSC was devoted to back-to-back, medium, and long loop tests (Figure 1) that did not require scheduling of TDRS H time. The second half of the demonstration used TDRS H for end-to-end tests (Figure 2). During the tests, Eb/No (signal to noise ratio) versus bit error rate (BER) data was collected to determine implementation loss at various BER points. By building up the test configurations in stages to reach the final end-to-end test configuration, it was possible to assess the effects of subsystem distortions on overall KaSAR-Wideband 650 MHz Intermediate Frequency (IF) service through a comparison of implementation loss observed during the various tests.

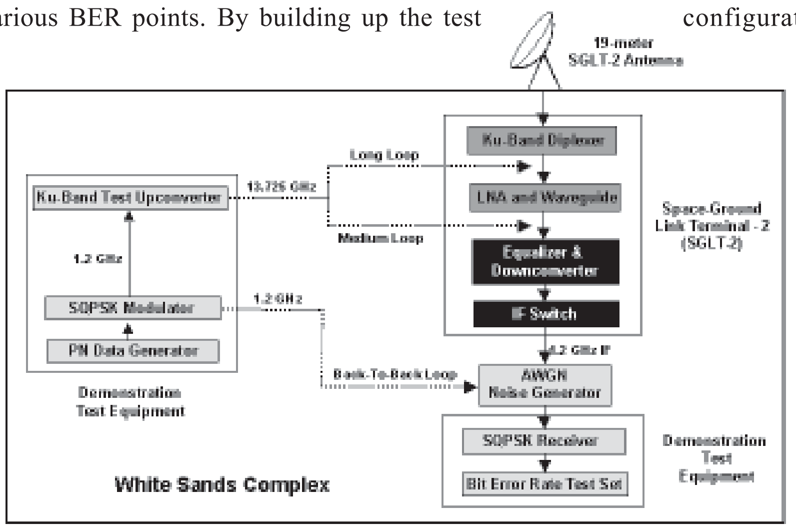
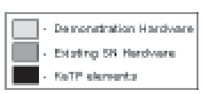


Figure 1. KaTP SN Demonstration Loop Back Test Configurations



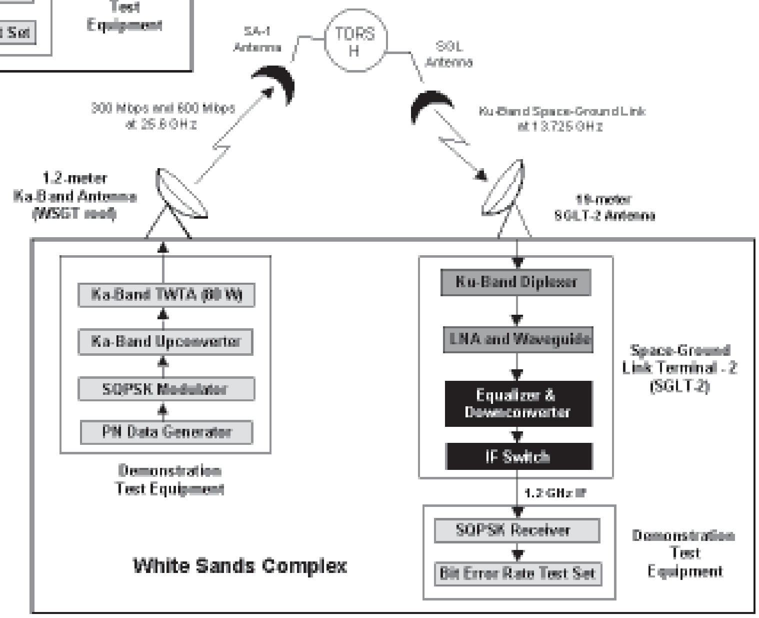


Figure 2. KaTP SN Demonstration End-to-End Test Configuration

Table 1 (at right) summarizes the demonstration results for the end-to-end TDRS H test in terms of implementation loss at a 10^{-5} and 10^{-7} BER. For the 600 Mbps total loss of 9.3 dB at a 10^{-5} BER, 4.0 dB is attributed to receiver losses and 5.3 dB is attributed to losses from other ground equipment and the TDRS H spacecraft. As indicated in Table 1, these results are consistent with predicted results obtained through high fidelity simulations. However, the end-to-end system implementation loss is higher than desired for customer services, and therefore efforts are underway to investigate the underlying causes and appropriate solutions.

One primary contributing factor to the end-to-end loss was the higher than expected receiver loss (4 dB) and its combined effects with other components in the system. In the months ahead, the KaTP project plans to perform additional high data rate characterization testing using all three Ka-band capable TDRSS spacecraft (if available).

Another significant milestone of note is the KaTP Operations Readiness Review (ORR)/ Transition Readiness Review (TRR) that occurred on February 11, 2003 for the SN upgrades. While there were a number of open items noted during the review related to the new implementation, the overall recommendation from the review was to proceed with the transition of the new services to operations. The new services are a KaSAR-Wideband IF Service using the TDRS H, I, J 650 MHz wide channel and a KaSAR Space Network Interoperability Panel (SNIP) service using the 225 MHz-wide channel.

Table 1. SN End-to-End Demonstration Results

Bit Error Rate	300 Mbps Measured Implementation Loss	300 Mbps Predicted Implementation Loss	600 Mbps Measured Implementation Loss	600 Mbps Predicted Implementation Loss
1×10^{-5}	4.0	Not Available	9.3 dB	9.8 dB
1×10^{-7}	4.9	Not Available	11.9 dB	13.6 dB

Notes:
1. Measured and predicted results are for SQPSK modulation with no coding.
2. No adaptive baseband equalizer (ABBE) was used during demonstration. Simulations indicate up to a 1.75 dB improvement (at 10^{-5} BER) may be achieved when using an ABBE.

Look for additional information on SN high data rate Ka-band characterization testing and customer services in future publications of *The Integrator*.

By Mark Burns/ITT Industries
For further information contact Yen Wong/GSFC Code 567 at 301-286-7446.

SN To Expand Ka-Band Customer Services

The Space Network (SN) currently offers customers partial Ka-band data services, using the TDRS H spacecraft and existing ground equipment at the White Sands Complex (WSC). Available services include Ka-Band Single Access Forward (KaSAF) service at data rates up to 7 Mbps, and Ka-Band Single Access Return (KaSAR) service at data rates up to 300 Mbps via the 225-MHz-wide channel.

As part of the SN Project's Ka-Band Transition Project (KaTP), NASA has upgraded the ground stations at the WSC to take advantage of the new TDRS H, I, J spacecraft's 650 MHz-wide channel for high data rate KaSAR service. A wideband (650 MHz-wide) Intermediate Frequency (IF) service has been implemented at four of the Space-Ground Link Terminals (SGLTs), by adding new downconverters and waveguide equalizers. The downconverters will receive the 650-MHzwide Ku-band downlink signal from TDRS H, I, J spacecraft and output a 1200 MHz IF signal. High data rate Ka-band customers will need to provide their own data demodulation, processing, and storage equipment compatible with the KaTP IF interface to obtain high data rate services via the SN.

The SN Project is planning to provide full end-to-end Ka-band data services to high rate SN customers in the future through implementation of the Ultra High-Rate Ka-Band User Services Development effort. Expanded Ka-band services will require additional enhancements to existing ground systems, beyond those implemented under the KaTP. Ground systems requiring upgrades include the WSC SGLTs, the Network Control Center Data System (NCCDS), and the User Planning System (UPS). Prime and redundant equipment will be required for data demodulation and decoding at each SGLT. Software modifications within the NCCDS and SGLT Automated Data Processing Equipment (ADPE) will also be required to support the scheduling, monitoring and control of the new high data rate equipment.

As a first step in implementing the Ultra High-Rate Ka-Band User Services capability, Project personnel are currently performing numerous trade studies that will:

1. Identify the optimum modulation and coding scheme for Ka-band return data services at data rates up to 1 Gbps through the TDRS 650 MHz-wide channel

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2. Derive the maximum allowable customer spacecraft transmitter distortions
3. Determine if Ka-band antenna Autotrack capability is required, versus Program track for the TDRS H, I, J spacecraft
4. Determine if a pooled receiver concept is acceptable, versus dedicated receivers for each SGLT equipment chain (similar to current SGLT architecture)
5. Identify the need for WSC data recording/rate buffering, versus WSC data processing versus real-time data transport for high rate services
6. Identify Ka-band antenna technologies for customer spacecraft
7. Evaluate the impacts of supporting Ka-band forward data rates above the current capability of 10 Mbps

By the conclusion of FY03, the Ultra High-Rate Ka-Band User Services Development team intends to:

1. Define the Operations Concept and Data Service architecture
2. Develop a Ka-Band Data Service System Requirements Document (SRD) that possibly includes Ka-band end-to-end test (EET) system requirements (The SRD development is the key objective of FY03 for this project, and is necessary so that implementation can proceed during following years)
3. Conduct an end-to-end data link demonstration at WSC at data rates of 1 Gbps or higher, if commercial hardware is available and if the results would benefit the Ka-Band Data Service project.

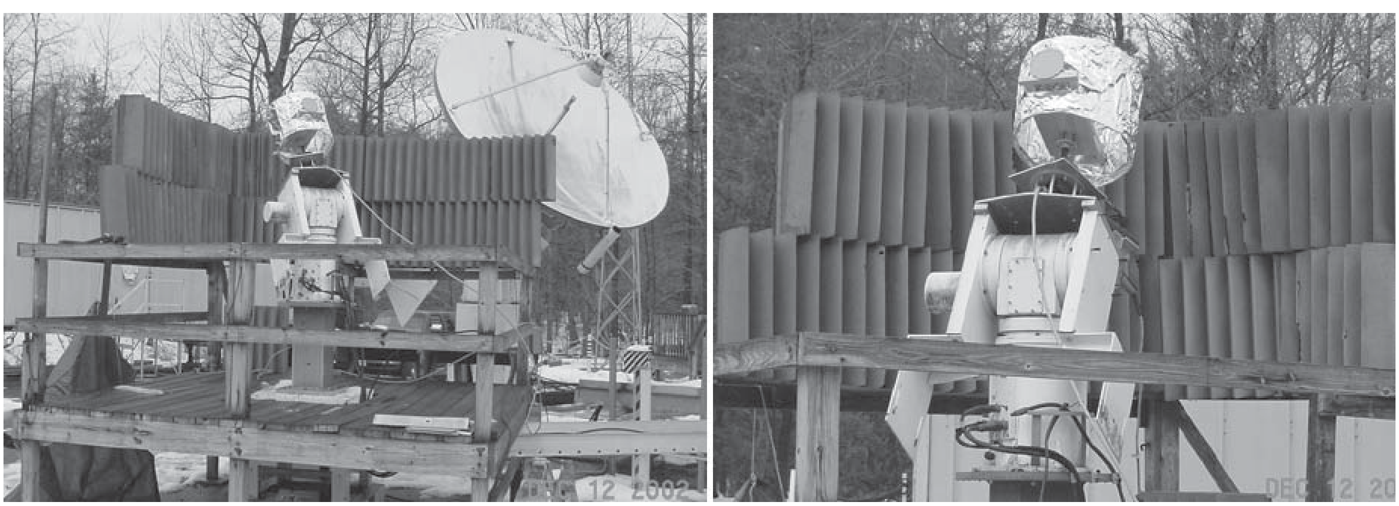
The above activities will be followed by the specification, procurement, and implementation of new hardware and software modifications necessary to support high data rate Ka-band data services. These procurement, implementation, and test activities are expected to be completed by the end of FY 06.

By Mark Burns/ITT Industries
For further information, contact Keiji Tasaki/GSFC Code 452 (Keiji.K.Tasaki@nasa.gov).

SN Demonstrates New Communications Ability

Many times, the Space Network (SN) is involved in interesting and challenging communications concept demonstrations. And on occasion, when “firsts” are attempted, the SN team may be requested to perform extensive analysis and testing to determine communications feasibility prior to flight demonstrations to ensure successful mission goals are accomplished.

A recent new mission involving communications from a dynamically moving vehicle has been one such challenge. The SN was asked to determine the possibility of supporting a vehicle that would be spinning at 105 RPM (1.75 rev/sec) near the end of its desired trajectory support. In the past, the SN has supported launch vehicles and spacecraft with much lesser spin rates—generally only a few RPM—with mixed success (signal fading, interferometering, etc.). Support has never been provided, however, to a vehicle with this fast a spin rate. An approach for analysis was developed, and then an actual Radio Frequency (RF) demonstration test was undertaken to determine support feasibility.



RF SOC mockup of vehicle on antenna pedestal
(Photos courtesy of Douglas Grove - CSOC/Honeywell)

Mission Services Program Office (MSPO) RF Communications Engineering staff performed considerable simulation and analysis, using the Communications Link Analysis And Simulations System (CLASS) tools. Frank Stocklin (NASA) led the groups involved in the analysis, and ITT Industries provided contractor support. The analysis required generating the combined antenna patterns for radiation originating from two omni-directional antennas simultaneously, and simulating the effects of the spin on the resultant power received (Prec) at TDRS with a very, very small step size. The resultant Prec was simulated with the TDRSS receiver characteristics to best determine the anticipated performance of the communications link at the White Sands Complex (WSC). The results showed that, although WSC is specified to have a Prec variation of 10 dB/sec, the receiver should be able to maintain lock on the signal with a variation of 10 dB/ 0.001 sec; but, the quality of the signal would be degraded. Now, could we prove the simulation and analysis before the real mission?

Obviously, a real spinning vehicle was not available for performing any RF testing via TDRSS before launch. So, given the CLASS analysis runs that profiled the anticipated communication link characteristics, Compatibility Test Van (CTV) and Radio Frequency Simulations Operations Center (RFSOC) personnel led by Frederick Gams and Douglas Grove (CSOC/Honeywell), showed exceptional initiative. They mocked up the front of the vehicle's body to scale (about the diameter of a large 55-gallon trash can) to reasonably emulate the customer communications system with antennas.

This GSFC RFSOC effort was accomplished with spare components lying around the Building 25 area, and $52 worth of parts. The mock-up was then mounted on a steerable antenna pedestal at the RFSOC to allow pointing at a TDRS to simulate various aspect angles. The mock-up used various improvised pulleys and fan belt arrangements, along with a remotely controlled rheostat motor (see photo). This arrangement allowed the entire vehicle front-end mock-up to be moved at different speeds and angles to essentially emulate a spinning vehicle transmitting its RF signal through antennas towards TDRS and WSC. Using the mock-up, the group was able to characterize the link's dynamic performance.

The successful completion of TDRSS/RFSOC RF tests, led at WSC by Bob Gonzales (GD), basically showed the CLASS analysis to be very close to the results observed at the WSC receivers when the mock-up was spinning at 105 RPM. A 10^{-2} bit error rate was anticipated and measured, good receiver/decoder lock was maintained throughout, and immediate RF reacquisitions could be performed at any time. We have now completed RF Compatibility Test Van interface tests with the real vehicle on the East Coast, and done direct TDRS RF tests in the launch area, at the time of this writing.

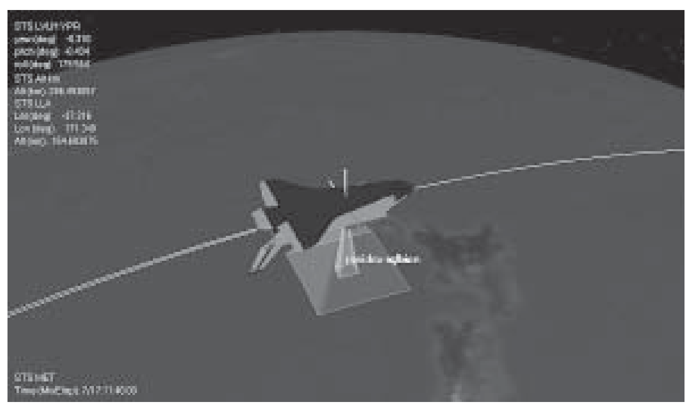
All those involved are anxiously waiting to see how the real SN mission support goes. This is the fun part of the communications business—to witness theory and reality coming together, knowing the discussions and efforts that went on "behind the curtain." The Smithsonian has not asked for the $52 mock-up, yet!

By Riley J. Elwood/ Fox, Herold & Associates

For additional information, please contact the author via telephone (301-286-6492) or email (Riley.J.Elwood.1@gsfc.nasa.gov).

FDF Develops Detailed Graphics for Shuttle-Based Experiments

FDF staff recently developed several systems used to display attitude-dependent Shuttle graphics. These systems were successfully implemented and used aboard STS-107. Interest was high in this mission as GSFC had many experiments aboard. For example, STS-107 was host to the Fast Reaction Experiments Enabling Science, Technology, Applications & Research (FREESTAR). FREESTAR is a complex secondary collection of instruments flown as a Hitchhiker payload. FDF developed a special utility that integrates the attitude data from the Shuttle to provide detailed graphics of the Shuttle orientation and the on-board experiments to the Hitchhiker Control Center.



Demonstration of STS and Instrument Attitude-Dependent Field-of-View

Another GSFC experiment aboard the mission was the Communications and Navigation Demonstration on Shuttle (CANDOS)/Low Power Transceiver (LPT). LPT is a low power, lightweight, software-programmable transceiver prototype technology demonstration that is being developed by NASA as

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a low cost S-band spacecraft navigation and communication device. (For more on this CANDOS experiment, see article on page 35.) The CANDOS/LPT prototype receives Global Positioning System (GPS) satellite signals for spacecraft navigation support, and provides both forward and return low rate data communication links to the Merritt Island, Wallops Island, and Dryden Flight Research Facility ground stations, and to the Space Network.

FDF team members John Bez and John Rowe are the principal architects of the two systems developed to show attitude-dependent Shuttle graphics. The first is a sophisticated graphics display system that utilizes the capabilities of the off-the-shelf PC components Satellite Tool Kit (STK) and AT&T's Viewer Communications Video display system (VNC). FDF team member Shawn Lindsey helped with the integration of the VNC system. The video system is integrated with an FDF-developed Telemetry Processor that ingests the telemetry from the NASA JSC Subsetter, which provides STS orbit and attitude information. The system has been further embellished with special views of the experiments aboard STS-107 with the help of Hitchhiker contractor Omitron and Mr. Lindsey. These videos are being well received in the GSFC community and FDF plans to host the video in the FDF Product Center to make it available to a wider audience.

The second system FDF developed is a MATLAB-based utility that provided detailed predictions of the LPT experiment aboard STS-107. The utility was used to generate attitude-dependent predictions of the LPT experiment, including information such as acquisition and loss of signal to three ground sites and the Space Network, the link margins, and the attitude angles relative to the Shuttle. This system was also validated before launch using the communications module in STK. In addition, Shawn Lindsey developed detailed procedures and training for FDF team members on the use of the LPT utility.

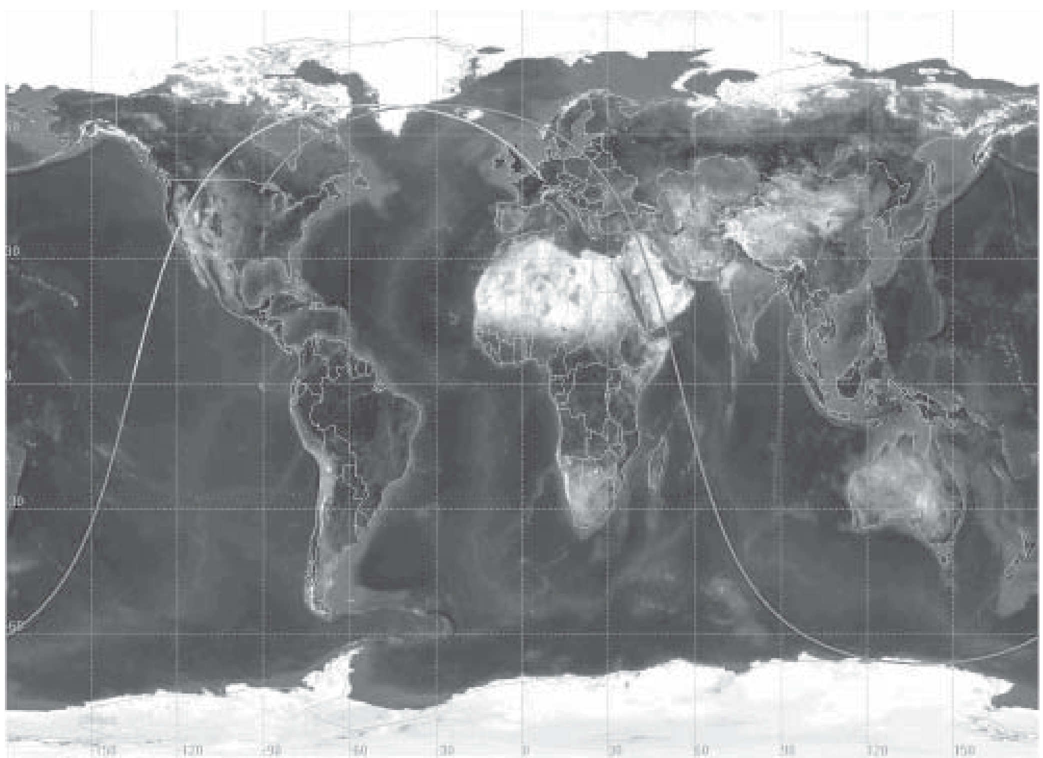
By Ann Nicholson/CSC

FDF Provides Prediction for Starshine-3 Reentry

As part of NASA's educational outreach program, the Flight Dynamics Facility (FDF) recently accommodated a request to predict the reentry date and location for the Starshine-3 mission.

Project Starshine is an educational initiative designed to increase students' understanding of aeronautics and physics. The spherical Starshine spacecraft are covered with mirrors and laser retro-reflectors, enabling observers on Earth to detect the spacecraft with the naked eye via reflected sunlight. Starshine-3 was nearly a meter in diameter (37 inches), weighed 91 kilograms (200 pounds) and carried 1500 mirrors that were polished by approximately 40,000 students in 100 schools in 30 countries.

Starshine-3 was visible to observers up to latitudes of 70 degrees north and south of the equator, who measured the satellite's position and recorded the precise timing of their observations. They then calculated the latitude, longitude and altitude of their observing sites and posted this information on the Starshine web site, permitting computation of the classical elements of the satellite's orbit. As the spacecraft experienced



Ground Trace of Starshine-3 Reentry

the effects of atmospheric drag, students measured the decrease in its orbital period, and deduced the density of Earth's upper atmosphere.

FDF personnel extracted current orbit state elements from the Strategic Command (STRATCOM) web site for use in the reentry analysis. FDF analysts carefully ran decay predictions and predicted a reentry date of January 21, 2003.

FDF's predictions gave an earlier reentry date than predictions done by other organizations; however, due to more accurate modeling of atmospheric data, the FDF predictions were closest to the actual reentry! The Starshine-3 spacecraft reentered the Earth's atmosphere above northern Canada or southern Greenland at approximately 0515 UTC on January 21, 2003.

FDF provided a reentry ground trace and predicted latitudes and longitudes for Starshine-3 to depict the actual reentry trajectory. These products are located on the FDF web site (*http://mmfd.gsfc.nasa.gov/reentry.htm*) to assist NASA in its educational outreach initiatives.

By Sherri Graham/CSC

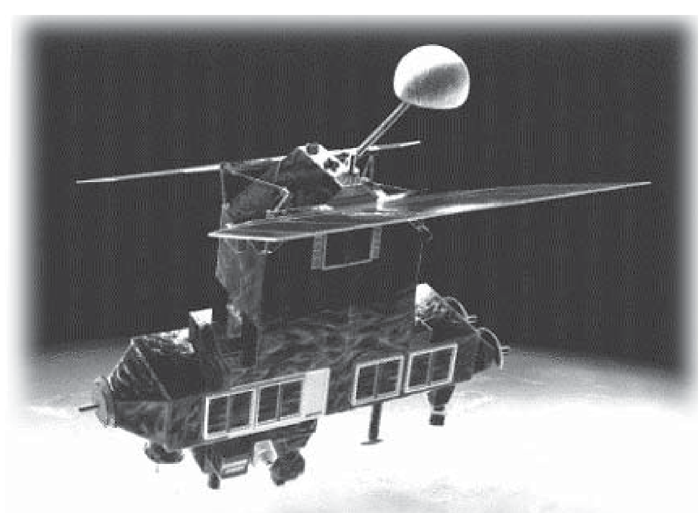
For more information on the Starshine Project, visit the project web site at http://www.azinet.com/starshine/.

FDF Designs and Executes Orbit Lowering Maneuvers for ERBS

The Flight Dynamics Facility (FDF) recently assisted NASA in lowering the perigee of the Earth Radiation Budget Satellite (ERBS) to shorten the remaining mission lifetime. The crew of STS-41G (of which Sally Ride was a member) originally deployed ERBS. The spacecraft's initial deployment was at an altitude of 610-km and an orbital inclination of 57 degrees, following a long ascent sequence which FDF members designed and executed. Since that time, ERBS had decayed to a 570-km perigee and 570-km apogee orbit. FDF projected the remaining mission lifetime from that orbit to be 18-20 years.

NASA strives to be a responsible member of the space community by removing its spacecraft from Earth orbit as quickly as possible after the useful mission lifetime has ended. Removal of the spacecraft reduces probability of collision with other spacecraft, or collision with debris that may fragment the spacecraft—two scenarios that could create a large orbiting debris field posing a danger to other space vehicles. ERBS is an aging spacecraft operating in a limited capacity. There was not enough fuel left on ERBS to provide for a controlled reentry, but there was enough to lower the ERBS orbit to reduce its lifetime.

To reposition ERBS, FDF designed a sequence of maneuvers that maximized the available power resources on the spacecraft, while enabling 20-minute deorbit burns. These sequences were intricately timed to begin 40-44 minutes before orbit noon, with the entire burn sequence performed in eclipse. This approach maximized the power positive charging on the Sun-side of Earth, assisting the delicate aging batteries aboard the spacecraft. The successful orbit-lowering sequence cut the projected remaining mission life in half, allowing ERBS to return to useful science in the meantime.



Artist's rendering of ERBS

ERBS was launched in 1984 to study how energy from the Sun is absorbed and re-emitted by Earth. This energy cycle is the principal driver behind Earth's weather patterns. ERBS has also been useful in studying the effects of Man on Earth's environment.

By Ann Nicholson/CSC

Space Network Access System To Provide a Single, Seamless Interface to SN

The Space Network Access System (SNAS) will provide a single, universally accessible low-cost, cross-platform and standards-based customer interface for performing Space Network (SN) scheduling and real-time service monitoring and control. The SNAS will consolidate the functionalities of the SN Web Services Interface (SWSI) and the User Planning System (UPS) into a single system, and will replace the UPS and SWSI as the primary scheduling interface between the SN customer and the SN.

The SNAS will build upon the cutting edge technology successfully used by the SWSI. However, SNAS will add some of the heavy usage features currently found in the UPS. Since the SWSI already

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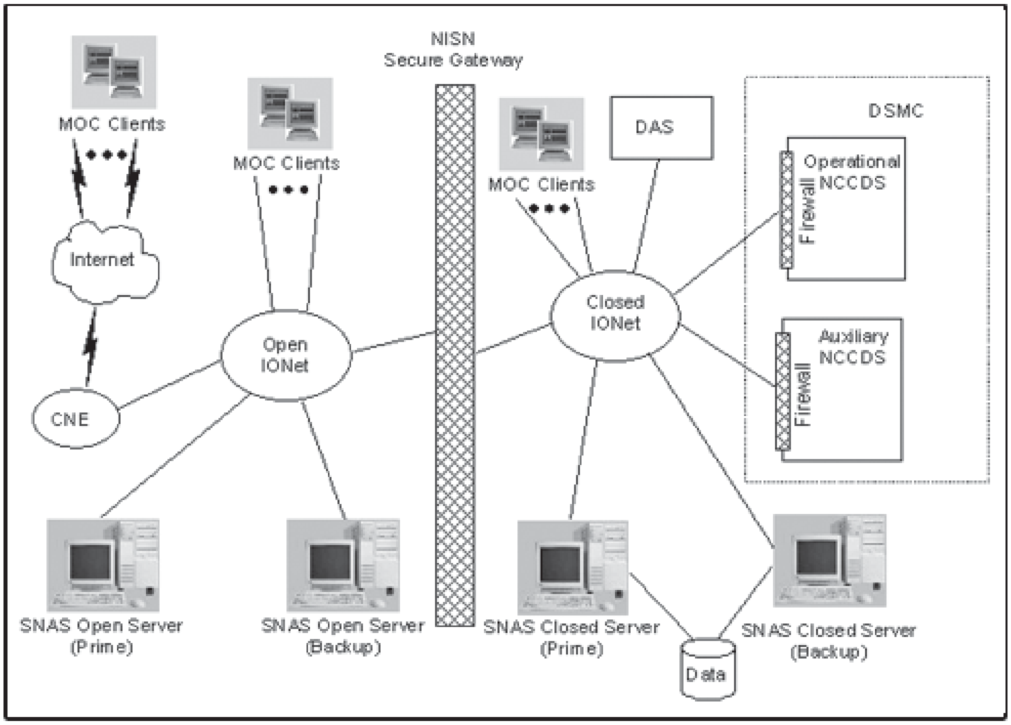

SNAS High-Level Architecture

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supports the SN Legacy services and the new Demand Access Service (DAS) MA Return services, the SNAS will round out its capabilities by adding Shuttle services and key UPS features.

This is an exciting time for us! Soon, the Mission Services Program will be able to offer a one-stop solution for SN services to our customers. Spacecraft projects will no longer have to build their own scheduling and real-time interfaces to the SN, thus saving time and money.

The SNAS is currently in the requirements analysis phase with a System Requirements Review scheduled for June of 2003.

By Joe Stevens/GSFC 565

For further information, please contact Joe Stevens via email at Joe.Stevens@gsfc.nasa.gov or by telephone at (301) 286-1557. For further information on SWSI, please contact Tom Sardella via email at Tom.Sardella@gsfc.nasa.gov or by telephone at (301) 286-7686.

Demand Access System Development Update

The November 2002 issue of *The Integrator* provided an update on the status of Demand Access System (DAS) integration and test and plans for the start of DAS operations. This article provides an update on the status of integration and test, including premission test activities with the Swift project and plans for the start of DAS operations in June 2003.

DAS is comprised of a variety of COTS hardware and software, along with customized programs tying all the various pieces together. DAS will expand TDRS Multiple Access (MA) return service capabilities by adding new receivers, monitoring tools, TCP/IP telemetry capabilities, and limited CCSDS data processing and distribution capabilities via the NISN IONet. ITT industries (the AES division in Reston, Virginia) is building DAS with Consolidated Space Operations Contract (CSOC) personnel providing systems engineering support at both GSFC and the White Sands Complex (WSC).

DAS is currently in the late integration and test phase. However, we are busily preparing for an early WSC Testbed capability to support premission activities with the Swift project. A formal Qualification Test Readiness Review (TRR) will tentatively be conducted in February 2003, at GSFC. Formal qualification testing begins in early March at the ITT Industries facility in Reston, and continues for 1 ½ weeks. The Pre Ship Review will be held in mid March.

The DAS interface to the Space Network Web Services Interface (SWSI), which will be used as the customer interface to DAS, continues to be tested in preparation for formal DAS-SWSI interface testing to be held prior to shipment to WSC. We are convening weekly meetings to facilitate the coordination of activities between the SWSI and DAS projects.

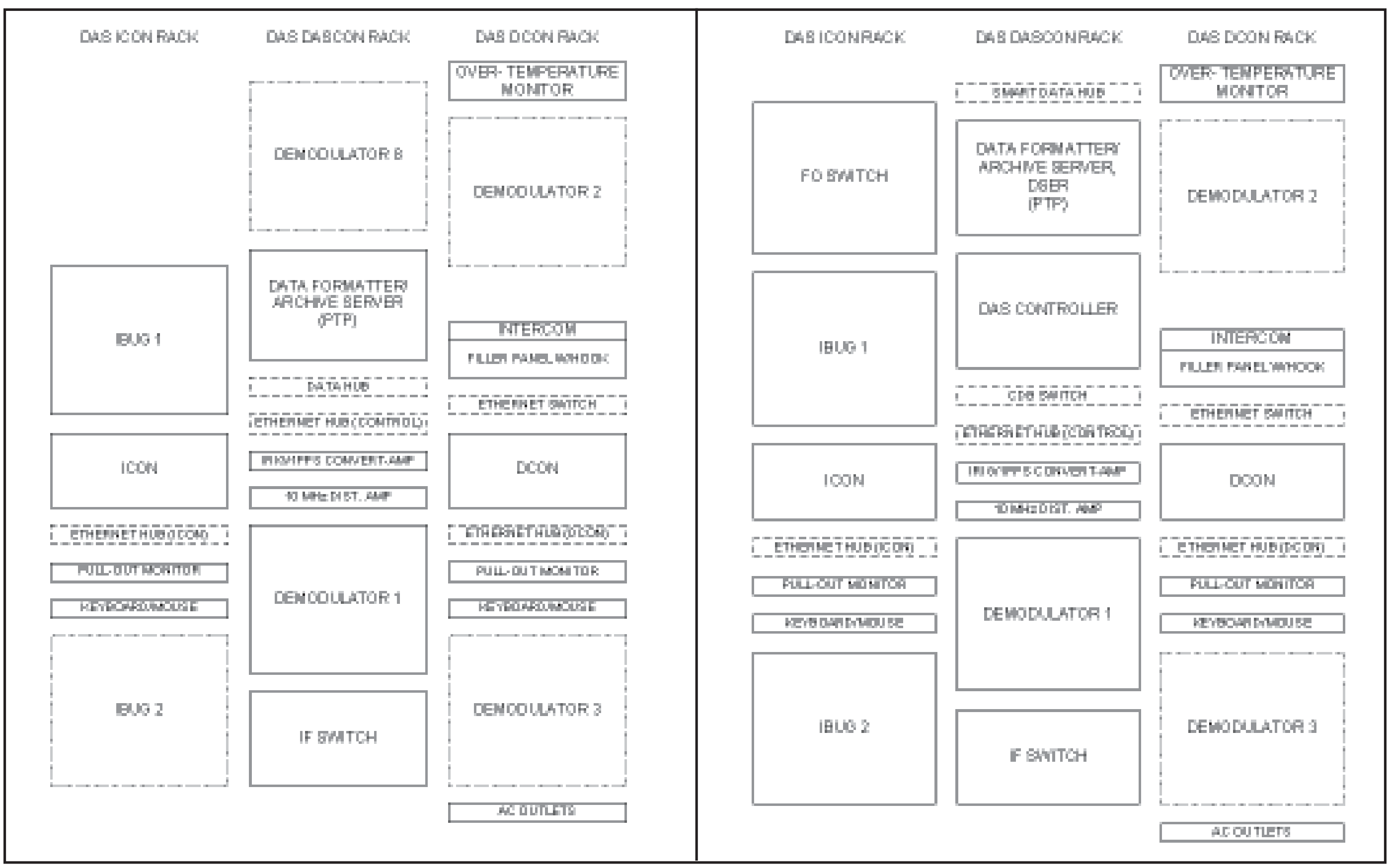
The effort to prepare for the Swift tests will help ensure that future customer support activities proceed smoothly. The testbed and the NISN communications lines, which will be activated for the testbed support, will be used for SPR/CAR work-offs, hardware integration, and other interface tests with Customers.

The DAS Website at *http://nmspc.gsfc.nasa.gov/das/* provides the history and goals for the project as well as DAS documentation such as the Test Readiness Review updates, the Operations and Maintenance Manual, DAS ground rules describing how customers can execute services, and the latest DAS schedule. The website also has useful links such as links to the SWSI website.

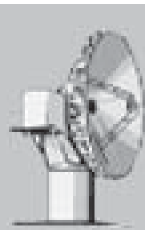
Potential future DAS customers include Aqua, Swift, AGILE, Aura, LDBP, C/NOFS and GPM. The respective Mission Managers for these projects are working with the DAS project, preparing to become DAS customers.

By Denise Gilliland/ITT

For additional information on DAS, contact Tom Gitlin/Code 452 via email (Thomas.A.Gitlin@nasa.gov).



Schematic drawings showing the specific equipment locations on the racks (pictured in the photo above). GRGT equipment is depicted on the left, and the WSC equipment is on the right.



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Ground Network Project

GN Evolution Planning Update: Examining Options for Best Value

The Ground Network (GN) Project continues to plan its evolution, focusing on an examination of future options for best value. (See the July and November 2002 issues for previous discussions on the GN Evolution Plan.) The Project has developed a high-level evolution plan that communicates key challenges and opportunities, and identifies an evolution vision. The GN team is now evaluating options and tradeoffs for implementing GN architecture changes.

The GN Project is customer driven, and will continue to provide reliable services to meet customer requirements. Beyond this fundamental goal, the GN Project has additional goals that guide GN architecture evolution. These goals are to manage risk, manage costs to avoid large capitalization, maintain minimum civil servant staffing, and balance long-term stability and flexibility of ground network capacity.

Challenges: Balancing Performance, Risk, and Cost in a Constrained Environment

Several key challenges drive GN evolution. Aging systems increase risk to service performance and increase maintenance costs. Mission-driven, non-standard interfaces and mission-unique hardware limit interoperability, which poses a performance risk, as well as a cost challenge. Flat budgets limit options for upgrades or new systems to address these issues.

In addition, the lack of flexibility in NASA's owned and "paid for" antenna capacity presents a cost challenge, because future customer demand for antenna capacity is predicted to change. In the short term, demand is predicted to significantly decrease as customers "fly out." In the long term, however, demand is relatively uncertain. Indeed, with the development of large constellation missions, dramatic year-to-year changes in customer demand are possible. The GN needs to develop the flexibility to match capacity to demand, so as to not pay to maintain significant unused resources.

Opportunities: Exploring Support from Other Ground Station Providers

Trends in the spacecraft control community may enable opportunities for future coordination that could help NASA reduce risk and perhaps reduce costs.

Within NASA, increased cooperation between spacecraft communications and data service factories could provide risk and cost benefits. Shared support will likely increase between the NASA Space Network and the GN. Some overlap in functionality for Earth-orbit support between GN and Deep Space Network may also enable greater cooperation.

Coordination between NASA and other government agencies also holds promise for risk and cost benefit. NOAA is a potential candidate for ground station cooperation. NOAA has indicated that ample X- and S- band contingency capacity exist on its ground stations. NOAA's current ground station architecture is similar to the GN, and with engineering enhancements may be capable of providing supplemental support to some current GN customers. In the future, the National Polar-orbiting

Operational Environmental Satellite System (NPOESS) Ka-band architecture, known as SafetyNet, may be able to provide high data rate capacity to NASA missions as well.

Though currently not as similar to the GN in capability and use as NOAA ground stations, the Department of Defense (DoD) satellite control infrastructure may provide interoperable capabilities in the long term. As it upgrades its systems, the DoD is exploring interoperability with other government satellite control systems, and may provide an opportunity for contingency support in the future.

Of course, commercial providers also provide significant opportunities for the GN evolution. Currently, some commercial providers maintain business viability in niche markets, while other providers rely on NASA as their cornerstone customer as they seek to develop a broader market. As commercial markets and ground station providers develop, they could provide an even greater benefit for the GN.

Vision: A Flexible, Reliable, and Competitive GN Architecture

The vision for the future GN focuses on providing best value services. In this vision, the GN provides core, multi-mission service capabilities and capacity, focusing on mission requirements. Due to budget and capital constraints, and the need for flexibility, commercial services may be competitive options for GN architecture evolution. Commercial services may enable GN evolution without large capital investments by NASA. There is potential that the GN may rely heavily on commercially owned and operated systems to provide its core capacity.

To supplement its core capacity, the GN may diversify its antenna provider mix with support from other organizations. This supplemental capacity could be from agencies such as NOAA, and would focus on GN contingency support, as well as support of the GN during launch and early orbit operations.

The GN project recognizes that there will be some situations where customer-unique science requirements will not be met through the GN or its supplemental providers. In these cases, the GN will coordinate with the customer and a customer-funded custom ground station service provider, to ensure that capabilities are not being duplicated.

Despite any increased reliance on commercial providers and cooperative partners, NASA will actively manage the GN and its evolution, overseeing contracts and budget as well as antenna scheduling. Decisions on the implementation of GN architecture changes and the selection of commercial providers will be based on best value. Active risk management is crucial and Government visibility into contractor processes is needed for effective risk management. In the GN evolution vision, the Government will utilize performance metrics to evaluate contractor risk management and mitigation processes, in addition to past performance indicators.

Options: Examining Current Tradeoffs

GN evolution planning activities currently focus on evaluating options and tradeoffs for implementing GN architecture changes. For example, the GN Project recently examined the impact of station power failures on customer requirements in the 2005 timeframe, and characterized the extent of NOAA support that would be required to help reduce risk. This study also revealed current antenna failure risks and identified critical and non-critical antennas in the 2005 timeframe. The GN Project is currently examining the future of the McMurdo Ground Station 10m antenna, assessing future customer needs and exploring GN architecture options.

The GN Project will continue to evaluate numerous options to support its ongoing evolution planning. For further updates, look forward to future issues of *The Integrator*.

By Luis Tsuji/Booz Allen Hamilton

Polar Bears and Spacecraft Tracking

Spitzbergen, Norway is probably more often associated with polar bears and extreme polar winters than with high technology and world-class satellite ground stations. This is now changing! For more than five years, NASA has used the site to track its polar orbiting satellites, and the Svalbard Ground Station (SGS) has become a well known term in the tracking community.

SGS is a part of the Svalbard Satellite Station (SvalSat), which is the northernmost ground station in the world. It is this extremely cool location on the Svalbard archipelago (at 78º 13' north) that provides SvalSat with its unique coverage capabilities. SvalSat is the only ground station able to provide satellite contact during all orbits for NASA (and most other) polar orbiting satellites. Needless to say, this coverage provides unique capabilities to owners and operators of polar orbiting satellites. For example, Earth observing satellites can perform a global data dump for each orbit at a single site. In addition, Telemetry Tracking and Commanding (TT&C) services can be performed on each orbit using one single ground station.

SvalSat History

The history of satellite tracking and command at Svalbard is

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long lasting. The European Space Agency (ESA) had one of its VHF stations on Svalbard back in early 1970. The station used now, however, is a new one located at a flat mountain above Longyearbyen, the main township founded by the American coal miner John M Longyear in 1901. The Norwegian Space Centre (NSC) and NASA built the current station as a joint venture. Between 1996-98 the station was designed, procured and constructed. This operation included the provision of access road, power, the station building and related infrastructure and all basic services.

In 1997 the former Tromsø Satellite Station, now Kongsberg Satellite Services (KSAT), started operations of the SGS on the Spitzbergen archipelago under a contract with NSC. Today KSAT has eleven people working permanently on the island. The station is manned around the clock, and operations and maintenance are handled by three shifts. The staff members also operate the antenna infrastructure installed by Space Data Services, a company established to provide support to NASA through the Consolidated Space Operations Contract.

During the initial optimisation phase of the service, several NASA teams visited the installation, which is located in a remote arctic desert. Apart from the obvious climatic peculiarities, there was the much spoken about danger of encountering polar bears outside the settlement. As a consequence, everybody leaving the settlement, or just walking between the equipment building and antenna radome at the station, had to be accompanied by station staff carrying large calibre guns.

SvalSat Antenna Infrastructure

NASA triggered the development at Svalbard by requesting a location for an antenna to be used for the Earth Observing System (EOS) Polar Ground Network. NASA-dedicated TT&C activities from SvalSat were initiated in 1997. SvalSat has provided support to many NASA missions, including Landsat-7, Terra, Aqua, ICESat, EO-1, SAC-C, Acrimsat, Champ, Grace, QuikSCAT, Kompsat, Cobe, Aqua, and QuikTOMS. Preparations for new NASA missions are also ongoing.

Today, the antenna infrastructure at SvalSat comprises three operational 11-meter S- and X-band systems used for both TT&C and data reception. The number of satellite customers signing up for services from Svalbard is continuously increasing. KSAT is therefore installing of a fourth complete multi-mission ground station (Datron 13 m), collocated with the existing systems. This system shall primarily serve the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) and NPOESS missions and is installed under a contract with the Integrated Program Office (IPO).

In addition, the European Meteorological Organisation, EUMETSAT, has decided that SvalSat will serve as the prime ground station for their EUMETSAT Polar System (EPS). This implies the installation of two complete EPS ground stations (10 meter antennas). KSAT has signed a contract with EUMETSAT to provide the polar site infrastructure and operational services for the EPS system. This program's METOP satellite is expected to launch in 2005.

A panoramic view of the plateau on Svalbard showing the antenna layout

Several other customers are currently evaluating the use of SvalSat for their polar ground station needs, and further antenna installations are being evaluated. The SvalSat site offers great flexibility and growth potential. In accordance with the goal of becoming the world's most important polar ground station, the site will be expanded according to the market demand.

Svalsat Operations Concept

SvalSat is manned around the clock by a team of 11 KSAT engineers and a manager responsible for the operations. These dedicated engineers are working permanently on Svalbard, carrying out all operations and maintenance at SvalSat. Additional managerial support for operations, special maintenance, financial administration, and quality assurance is granted from KSAT in Tromsø, Norway. Two engineers staff the station at all times, and are prepared to take action on-site if anomalies occur.

One of the antenna systems available at SvalSat (the NASA-dedicated system) is operated locally by this KSAT crew. The remaining three antennas (including the new IPO antenna) are remotely controlled and operated from Tromsø by the Tromsø Network Operations Centre (TNOC)—a part of KSAT. In December 2000, TNOC was fully certified, and has been providing operational S-band support for several NASA missions.

TNOC is also to be the point of contact for customers using future multi-mission antennas at Svalbard Satellite Station. Scheduling contact will be accomplished with a TNOC operator (by e-mail or voice communications). At all times, two engineers will staff the TNOC, and will be available for requests regarding operations or technical support.

A view of the inside of the KSAT operations room at Svalbard

KSAT today operates two ground stations—in Tromsø and at Svalbard. Continuity and experience are important factors when operating an advanced technical installation like a satellite station in the Arctic. Engineers at the Tromsø office and the Svalbard site are therefore viewed as members of the overall KSAT team. There is a common personnel pool in Tromsø, and the engineers are from time to time rotated between Tromsø and Svalbard. In this way technical competence and Arctic experience are maintained within the organization.

By Rolf Skatteboe
Administrerende Direktor /
President
Kongsberg Satellite Services
a.s. N-9292 TROMSO, Norway

For additional information, please visit the KSAT web site (http://www.ksat.no).

TDRS Project

TDRS-J: Launched Without a Hitch!

The TDRS-J spacecraft was successfully launched from Space Launch Complex (SLC) 36A at the Cape Canaveral Air Force Station (CCAFS) on a Lockheed Martin Atlas IIA launch vehicle on December 4, 2002. Liftoff occurred right on schedule, at 9:42 PM EST. Just under three minutes after liftoff, the first stage booster engine was shut down, and the booster engine package was jettisoned from the Atlas vehicle. The payload fairing was jettisoned about 50 seconds later, as the first stage continued to ascend on the booster sustainer engine. The sustainer engine was shut down at 4-1/2 minutes after liftoff, and the Atlas booster separated from the Centaur second stage.

TDRS-J was successfully launched on December 4, 2002, at 9:42 PM EST.

A few seconds later, the Centaur's main engine was prepared for the first Centaur burn that began just under five minutes after liftoff. Centaur main engine cutoff occurred nine minutes and 46 seconds into the flight. After a brief coast period, the Centaur engine was re-ignited and burned until all the available fuel on the Centaur stage was used, providing the TDRS-J spacecraft with the maximum energy transfer orbit. The Centaur main engine shut down just under 26 minutes after liftoff, and the spacecraft nominally separated from the Centaur at 29 minutes, 40 seconds after liftoff.

The Atlas IIA launch vehicle provided a very good transfer orbit for TDRS-J. The orbit perigee was 222 km, the apogee was 31,543 km, and the inclination was 27 degrees. During the two-week period following the launch, controllers at the Boeing Mission Control Center completed a series of orbit raising maneuvers with the satellite's Liquid Apogee Motor. This boosted TDRS-J into a geosynchronous orbit, 35,785 km above Earth's equator. After the completion of the orbit-raising maneuvers, all appendages of the spacecraft were successfully deployed, and TDRS-J was moved into an on-station Earth-pointing configuration at its testing location of 150° West longitude.

Handover of control and operations of the spacecraft from the Boeing Mission Control Center to NASA's White Sands Complex occurred on December 18, 2002, which marked the beginning of the on-orbit testing of the spacecraft. Bus on-orbit testing was completed as planned, and payload activation and calibration phase of the on-orbit testing began in January 2003.

The TDRS-J launch was delayed from November 20, 2002, to allow additional time for KSC and Lockheed Martin to clear the Centaur RL-10 engine for flight. A similar RL-10 engine used on another launch vehicle had experienced a failure during ground testing. The extra time was required to determine a most probable root cause for the failure, and assure the launch team that the Centaur RL-10 engine would not experience a similar failure during the TDRS-J launch.

The Atlas IIA vehicle used for the TDRS-J mission was the last Atlas IIA to fly, ending a 10-year record of successful flights for this version of the Atlas launch vehicle.

TDRS –J is the third in a series of enhanced satellites (built by Boeing Satellite Systems of El Segundo, California) that will provide researchers with data and images from several NASA missions.

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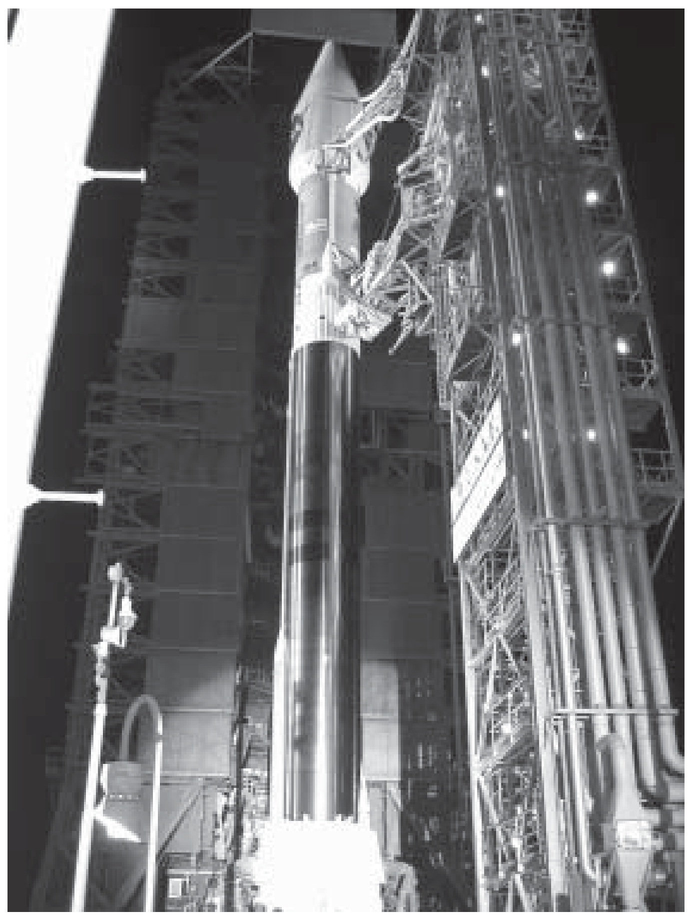

The Lockheed Martin Atlas IIA launch vehicle carrying TDRS-J poised on the launch pad at the Cape Canaveral Air Force Station (CCAFS), awaiting the final countdown.

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"This state-of-the art communications system will support NASA's overall mission by helping us better understand and protect our home planet, explore the universe, search for life, and inspire the next generation of explorers," said Bob Jenkens, TDRS Project Manager.

By Mike Goeser/GSFC Code 454

For more information about TDRS H, I J, please contact the author via telephone (301-286-0427) or email (Francis.M.Goeser@nasa.gov).

TDRS Resident Office Hosts VIP For Launch

The spectacular night launch of TDRS-J was a really fantastic event for the folks in the TDRS Resident Office (Bing Joe, Donald Neudecker, Tonni Hemphill and Paul Nordin). Special guest Herbie Hancock—a talented and accomplished jazz musician—was invited to the TDRS J launch by our dedicated administrative assistant, Tonni Hemphill. On the day after the launch, Mr. Hancock enjoyed special VIP treatment at Kennedy Space Center (KSC), and toured several NASA facilities. The accompanying photo shows Mr. Hancock with staff from KSC and the TDRS Resident Office.

With TDRS-I on-orbit checkout complete, and TDRS-J about to begin on-orbit testing, NASA acceptance of TDRS-I and TDRS-J will be our next major activity. Boeing Satellite Systems (BSS) will be presenting (1) satellite state of health and (2) satellite ability to accomplish the 15-year mission life, for both satellites prior to NASA acceptance.

The Resident Office was moved to a different physical location, at the BSS facilities. We are now located in BSS building S05 on the fourth floor.

By Paul Nordin/GSFC Code 454 and Tonni Hemphill/GSFC Code 454

Herbie Hancock tours NASA facilities at KSC. Pictured from left to right are: Don Neudecker, Herbie Hancock, Welmon Speed (NASA/KSC Customer Integration Manager), Delores Abraham (NASA/KSC Public Affairs Specialist), Tonni Hemphill and Derwood McKinley (NASA/KSC ASRS System Manager)

SPACE NETWORK • TECHNOLOGY • GROUND NETWORK • STANDARDS

Crosscutting Activities

LPT CANDOS Experiment Conducts Fully Successful Shuttle Flight

The Low Power Transceiver (LPT) Communications and Navigation Demonstration on Shuttle (CANDOS) experiment had a fully successful flight on board STS-107. CANDOS was a part of the FREESTAR (Fast Reaction Experiments Enabling Science Technology Applications and Research) HitchHiker Payload. (To learn more about FREESTAR, please visit the project's home page at *http://sspp.gsfc.nasa.gov/hh/freestar.html*)

The CANDOS flight hardware consisted of a first generation LPT integrated with a commercial processor board functioning as the flight computer, along with an S-Band Receive Antenna, GPS Antenna, Low Gain Transmit Antenna, and High Gain Transmit Antenna. The CANDOS experiments included Space Network (SN) communications and Ground Network (GN) communications, GPS Navigation, Space-Based Range Safety, Mobile Internet Protocol (IP) and other IP in Space

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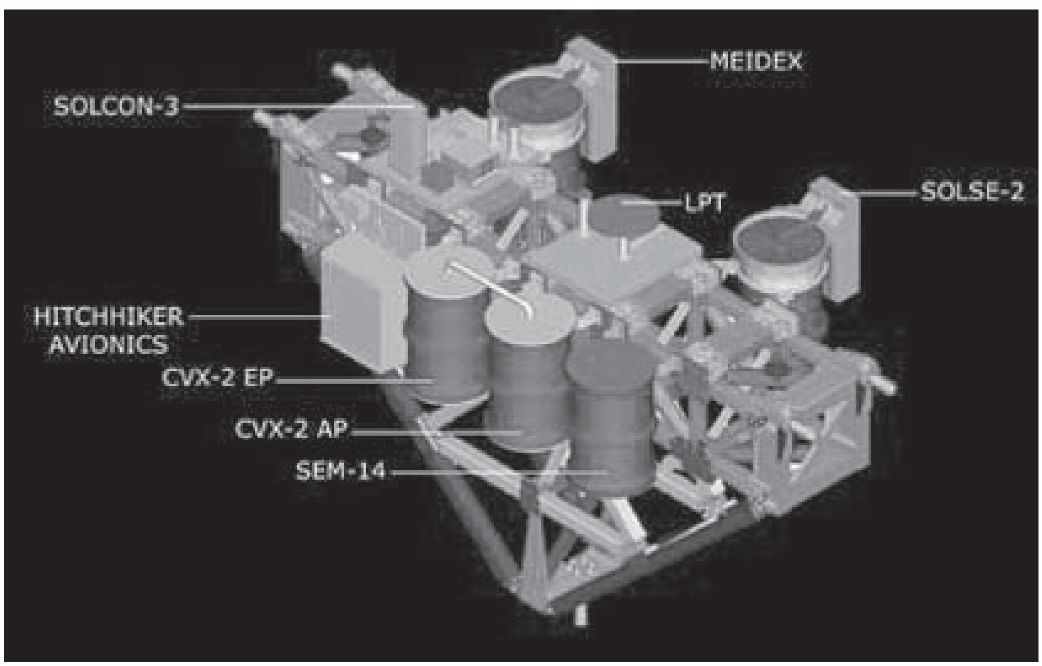

Artist's rendering of the FREESTAR payload that flew onboard STS-107.
A part of FREESTAR, the LPT CANDOS experiment successfully demonstrated several important space communications technologies.

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applications, On-Orbit Reconfiguration, and Educational Outreach activities. Every goal of the mission was met or exceeded during the course of the flight.

SN/GN Communications

The LPT is a multi-channel, software programmable transceiver, capable of transmitting and receiving SN mode or GN mode S-Band signals, while simultaneously receiving L- Band GPS signals. Throughout the course of the mission, the LPT experiment completed 97 SN events and 37 GN events totaling almost 60 hours of contact time. During approximately half of the events, the Shuttle's attitude was varied to keep the experiment's fixed-pointed antennas at the target TDRS or ground station. The rest of the events were accomplished by scheduling events based on highly accurate view period predictions based on Shuttle attitude and position, and provided by the Flight Dynamics Facility.

The SN events utilized S-band Single Access, Multiple Access, and S-band Multiple Access services with data rates as high as 128 kbps supported on both the forward and return links. Both the Wallops Ground Station and the Merritt Island Launch Annex supported the GN events. The GN uplink was the standard two kbps on a 16 kHz subcarrier, and the downlink was 128 kbps modulated onto a 1.024 MHz subcarrier.

LPT successfully accomplished 89% of the events, gathering data well in excess of the minimum requirements. Eight percent of the events were partially successful, and five events were outside of predicted antenna field of view. None of the unsuccessful events appear to be due to LPT RF hardware—the explanation for most cases is misconfiguration.

GPS/Navigation

This experiment demonstrated the ability to acquire and track GPS signals while on-orbit, and to autonomously perform orbit determination. Success was measured by the acquisition, tracking, frame synchronization and metric generation of greater than four GPS signals simultaneously, and the generation of valid point solutions and state vectors for the Shuttle. The LPT processes GPS signals, performs code and carrier phase measurements, and maintains an estimate of time. It also recovers and decodes each tracked GPS spacecraft's ephemeris and almanac broadcasts. In addition, the LPT estimates position and velocity (i.e., the state vector) of the Shuttle.

Four GPS events occurred during the mission (consisting of a minimum of two hours of consecutive time without Shuttle attitude maneuvers). After each GPS operation was initiated, the navigation software automatically maintained track of the GPS constellation using the Shuttle attitude, and did not require any operator intervention for the duration of the experiments. Position difference was measured within the uncertainty of the JSC vector, ranging from 25 to 250 m. The Navigation Filter (GEODE, which was developed by the GSFC Guidance, Navigation and Control Center) measurement residuals were generally well within +/- 20 m over each two-orbit experiment, indicating that GEODE is meeting its performance expectations (20 m, 1-sigma).

Range Safety

These experiments demonstrated the use of a space-based platform to support range safety activities, with the TDRSS constellation providing continuous coverage through ascent, orbital operations, and landing. Success was measured by the receipt and turnaround of commands by the LPT (a minimum of three successful, with no dropout passes) with each pass consisting of simultaneous contacts with one TDRS and one GN station.

LPT successfully completed twelve range safety events: five Dryden-only events for 29 minutes and 30 seconds; one SN-only event for 15 minutes and six dual Dryden/SN events for over 20 minutes of dual coverage time. The link was closed and error-free packet data flowed for all events. Post-flight analysis will be required to confirm that the range safety events were conducted with a link margin of 9 dB. Initial data indicates that most passes exceeded the 9 dB link margin requirement from the Range Safety community.

Mobile IP/IP-in-Space

CANDOS featured Mobile IP and IP-in-Space demonstrations that were developed and performed by the GSFC Operating Missions as Nodes on the Internet (OMNI) group. LPT CANDOS provided the first on-orbit demonstration of Mobile IP. All communications via the SN and GN utilized IP packets in High Level Data Link Control (HDLC) frames on the RF links. A Cisco router (provided by NASA Glenn Reseach Center, along with some Mobile IP expertise) was interfaced to the data streams at each ground station, and configured as a Mobile IP foreign agent. The GSFC-developed Ground Station Router Interface Device (GRID) provided this interface. When the CANDOS RF link was established with each ground station, Mobile IP automatically configured all data routing between the Payload Operations Control Center (POCC) and the flight hardware. There was no need for any pre-pass data line configurations.

IP-based protocols and applications used and evaluated included: Multicast Dissemination Protocol (MDP), Network Time Protocol

(NTP), Secure Shell (SSH) and Telnet, Secure Copy (SCP) and FTP.

The standard off-the-shelf IP stack built into the on-board COTS operating system (Red Hat Linux 6.1) supported all data communications. Highlights of the demonstrations included the following:

- Standard HDLC packet framing used on all links
- Packet routing established automatically and securely (using the standard Mobile IP protocol that comes with Cisco routers) on all two way SN and GN events
- Blind commanding using User Datagram Protocol (UDP) based command uplink
- Real time telemetry delivered using UDP
- Reliable file delivery from payload to POCC (navigation system logs, communications system logs) and from POCC to payload (stored commands, data files, software updates) using both TCP/IP-based, two-way file transfer protocols (SCP) and one- and two-way UDP-based MDP
- On-board clock synchronization to ground time standard using NTP
- Autonomous on-board message data routing demonstration
- Secure commanding from, and reliable file delivery to a remote site (NASA/MSFC)
- Multiple simultaneous secure sessions between the POCC and the spacecraft conducting commanding and reliable file transfers
- Multi-station reliable file transfers (automatic resumption after handover)
- File delivery across one-way links with application-level Reed Solomon coding.

On-Orbit Reconfiguration

The LPT is a software-based radio, with the core receive and transmit functions running in Field-Programmable Gate Arrays (FPGAs) and a Digital Signal Processor (DSP). This technology provides the option of reconfiguring a transceiver after launch. Two SN passes were utilized to demonstrate reconfigurations of the LPT DSP. The first reconfiguration tested the method by reloading the currently operating code to demonstrate the on-orbit process. The second reconfiguration included a file transfer of new DSP firmware from the ground that was subsequently installed in the LPT. The new firmware included minimal code modifications, but it was verified to be installed and working during the following SN events.

Educational Outreach

A high priority secondary objective for LPT was to promote public interest and education about NASA and satellite communications. Ten different schools and organizations provided "test files" for use during the CANDOS experiment. These files included pictures, drawings, or signatures of students from schools close to GSFC and as far away as England. These files were utilized during file transfer operations from the ground to the payload and back.

LPT CANDOS was a highly successful experiment. Many papers about the various demonstrations will be written and presented in the upcoming months. The results will influence future mission operations and technology, and be a continuing tribute to the STS-107 mission.

By Dave Israel/GSFC Code 567

For additional information on CANDOS, please contact the author via email (david.j.israel@nasa.gov) or telephone (301 286-5294), or visit the web site (http://ipinspace.gsfc.nasa.gov/CANDOS/) .

GSFC Personnel Help Define NASA Technical Standards

GSFC personnel are active members of the Consultative Committee for Space Data Systems (CCSDS), an international organization whose members work to provide optimized solutions (called CCSDS Recommendations) for space mission data handling needs. In this article, we summarize the recent activities of the various panels and GSFC representatives.

Panels 1A/1F (Protocols/Advanced Orbiting Systems): GSFC hosted and participated in the Subpanel 1A Technical Interchange Meeting (TIM) held at the GSFC Magnetic Test Site on January 29, 2003. The GPM (Global Precipitation Measurement) mission has expressed an interest in assessing the CCSDS File Delivery Protocol (CFDP) for use on that mission. Personnel from the James Webb Space Telescope (JWST) and CCSDS are discussing the best way to use CFDP on the JWST mission. They have recently raised their science data rate from 10 megabits per second to 100 megabits per second. [Technical Representative Tim Ray/GSFC Code 584]

Panels 1B/1E (Channel Coding/Modulation): GSFC hosted the P1E Fall 2002 meeting in Annapolis, MD. Goddard achieved consensus on a new Red Book for the CCSDS RF and Modulations Systems. This new Recommendation will allow missions to use a simpler Non-Return to Zero (NRZ)/suppressed carrier modulator system, reducing transceiver/transponder complexity and requiring half the bandwidth. The team started discussions on the need for a higher level error correcting coding technique called Tornado Codes, originated by JPL. These codes would likely operate at the CFDP level, providing files or products the ability to correct bad or missing frames. [Technical Representative Wai Fong/GSFC Code 564]

Panel 1J (Navigaton): The team completed the updates to the Orbit Data Messages Red Book at the Fall 2002 workshop, making this Recommendation ready for promotion to approved (blue book) status. However, the management council determined that the Recommendations must be adaptable to XML (eXtensible Markup Language) and Parameter Value Language (PVL) formats. The document is now undergoing additional updates to comply with XML/PVL. The team also drafted a white paper on space object identification requirements. [Technical Representative Felipe Flores-Amaya/GSFC Code 450]

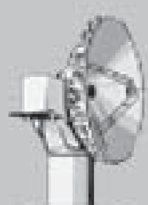
P1K Spacecraft Onboard Interfaces (SOIF): The team has been supporting a trade study to use a standard interface (i.e., Ethernet) for the GPM spacecraft inter-processor communications bus. We have also been working with JWST to standardize the SpaceWire network and transport layers for use in the JWST instruments. A SpaceWire network simulation was developed to test a SpaceWire network/transport concept. This concept will be submitted to the SpaceWire working group and the full SOIF panel. In spring 2003 we plan to start draft green books for a Spacecraft Inter networking service, a Spacecraft Intra-networking service and Network management. [Technical Representative Richard G. Schnurr/GSFC Code 560]

Panel 2 (Information Interchange Standards): GSFC personnel gave the opening remarks as an invited speaker to the CNES symposium in Toulouse on "Ensuring the Long-term preservation and adding value to scientific and technical data." A GSFC representative also presented "Standards Based Science Data Archiving at NSSDC" at the CNES symposium, and chaired the session on Future Directions. The team prepared an article for the *National Space Science Data Center (NSSDC)* newsletter on the implementation of CCSDS/ISO Archive Reference Model concepts for the migration of tape data within the NSSDC. [Technical Representative Donald Sawyer/GSFC Code 633]

Panel 3 (Cross Support Operations): Development of the SLE Service Management/Service Request Specification continues. A CCSDS Panel 3 Working Group 1 meeting was held in Pasadena, California, USA, January 28 - 30, 2003. Attendees included representatives from NASA/JPL, NASA/GSFC, British National Space Centre, and NASA/JSC. The meetings focused on the structure and content of W3C XML schemas, coordination of standard/W3C XML schema development efforts, and standard production schedule. The first draft version of the candidate XML schema standard is to be made available in March 2003. Draft red books and green books, for the specification and concept document respectively, are to be provided by late March in time for the spring 2003 CCSDS meetings. [Technical contact: Tim Ray/GSFC Code 586]

OMG (Object Management Group): GSFC personnel participated in the OMG Space Domain Task Force (SDTF) Technical Meetings held the week of November 18 in Arlington, VA. An initial draft of the Telemetry and Command (T&C) Data Definition Specification (i.e., RFP-1, a standard T&C XML schema) was submitted to the OMG Architecture Board, but it was agreed that a new draft would be submitted at the January 2003 meeting. The main objective is to get the RFP-1 Specification (XML-based Telemetry and Command Data Base) approved to begin a prototyping phase. Several OMG Space Domain Task Force members will test with this new database approach throughout the year to identify any problems. [Technical Representative Mike Rackley/GSFC Code 581]

For further information, please contact Felipe Flores-Amaya, GSFC Data Standards Manager, at 301 286-9068, or visit the CCSDS web pages (http://www.ccsds.org).



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